To HIS EXCELLENCY, SIR JOHN ANDERSON, K.C.M.G.,

Governor of the Straits Settlements, and
High Commissioner for the Federated Malay States.

SIR,

I have the honour to submit the report on the Sanitary condition of Singapore.

Valuable assistance rendered by the Officers of the Government and of the Municipality.

In connection with the preparation of the report, and the investigations which it entailed, very valuable information and assistance, as well as plans, have been given to me by both the Officers of Government and the Officers of the Municipality.

In the service of the Government I would particularly mention Dr. McDowell, the Principal Civil Medical Officer; the Honble. Mr. Murray, the Colonial Engineer; Dr. Mugliston, the Acting Principal Medical Officer; Mr. Dent, the Government Analyst; Dr. Finlayson, the Government Bacteriologist; Dr. Freer, the Principal of the Singapore School of Medicine; and Mr. Ridley, Director of the Botanical Gardens. And in the service of the Municipality, Mr. Pierce, the Municipal Engineer; Dr. Glennie, the Acting Medical Officer of Health; Mr. Mayhew, the Chief Sanitary Inspector; and Dr. Middleton, the Health Officer, who saw me in London. It is due to their hearty co-operation and anxiety for the sanitary welfare of Singapore that I have been able to ascertain and point out in this report the weak spots in the sanitary system. I have also to acknowledge with thanks the assistance I received from Lieut.-Colonel Johnstone, R.A.M.C., the Senior Military Medical Officer of the Straits Settlements, and from Colonel Sankey, C.R.E. I also received much assistance from the medical profession practising in Singapore, especially with reference to enquiries relating to malaria.

Sanitary defects due largely to old-standing structural conditions, &c.

In reporting the sanitary defects, it is necessary, in order to prevent any misunderstanding or blame, to state at the commencement that many of them are due to old standing structural conditions, which only new laws can deal with, while others are due to systems which are no longer applicable to a town of the size of Singapore, but to replace which requires a large expenditure. Whenever the Municipal Engineer has had the designing of new works, such as the proposed waterworks, they are on a scale worthy of Singapore. The defects mentioned in the departments under his control are largely a matter of inheritance.

As regards the administration of the Health Department, a perusal of the old reports when Dr. Middleton was appointed, and a comparison of the conditions then prevailing, with those now existing, as ascertained by inspection, shows a great transformation and improvement effected under very great difficulties.

It has always to be borne in mind that the population of Singapore is a peculiar one, in that the immigrants which form so large a proportion of its inhabitants are mostly people from the rural districts of other countries, and are unaccustomed to the restrictions and practices of town life, and that though the population is quiet and amenable, yet many difficulties are encountered in the town in connection with its sanitary administration that are not met with to the same extent elsewhere.

I have the honour to be, Sir,

Your obedient Servant,

W. J. SIMPSON, M.D., F.R.C.P.

King's College, London.

February, 1907.

Report

ON THE

SANITARY CONDITION OF SINGAPORE.

SITUATION AND CLIMATE.

1. Importance of Singapore.

Situated at the Southern entrance to the Straits of Malacca, the town of Singapore owes its great importance to the fact that it faces the narrow gateway of the maritime trade route between the Indian and Chinese seas. It thus not only commands the strait through which the ships of the world pass in going to and from the Far East, but its port, which is one of the largest and most picturesque in the East, is in the forefront of sea commerce, and so many ships enter its harbour that its shipping tonnage is the eighth largest in the world.

2. Its rapid development.

It is difficult to realise that though the town of Singapore has been in the possession of the British only some eighty-seven years it has undergone during that time a remarkable change, effected by the activity and enterprise of its owners. When taken over by Sir Stamford Ruffles in 1819 it was a fishing village with about 150 inhabitants, and with hardly sufficient clear space on which to pitch the tents of his Sepoys ; it was covered with thick jungle on its higher portions, and with mangrove swamps on its lower. Now it is a thriving town of nearly a quarter of a million inhabitants, with excellent roads leading into the interior.

Such a development has not been easily attained.

The site on which Singapore is chiefly built has entailed enormous exertions to bring it to its present position. Originally consisting of small hills and extensive swamps, the material from the hills has had to be removed to reclaim the swamps, and the major and older portion of the town is now situated on land which has been reclaimed from swamps or from the sea, or on land the site of former hills.

This reclamation has proceeded with varying degrees of progress at different times. At the present time extensive reclamations are being projected. Thus, at Tanjong Pagar, situated in the South-western portion of the town, and where there is a splendid natural harbour, some large swamps are to be dredged out to form new graving docks for the accommodation of large ocean-going steamers, the spoil earth being used for filling up some adjacent mangrove swamps.

Again, North-east of these, and more towards the central portion of the town, which faces the sea, some 88 acres of land are to be reclaimed from the sea in connection with the proposed harbour improvements. This reclaimed land is intended to be used for warehouses and wharfage. The front will be made into a quay for the inner basin, which, with an outer

basin, is to form the main feature of the new harbour works, having for their object the accommodation and shelter of the inter-colonial and other small steamers now exposed to the North-east monsoon.

These are Government works.

3. Topography.

The town of Singapore extends along the coast from North to South for 9 miles and inland $4\frac{1}{2}$ miles, embracing a total area of 40·5 miles. This area is traversed by three series of hills, which, with their numerous diverging spurs and low-lying valleys, run from East to West and join an irregular range extending in a southerly direction and ending at Mount Faber. In the most southern valley formed by these hills is the Singapore River, in the next is the Brasah Bras River, now called the Stamford Canal, and in the third is the Rochore River, all of which enter the sea in front of the town. The Rochore River is joined at its mouth by the Kalang River. They are tidal rivulets, and as will be seen later swamps of an extensive character are formed in their vicinity, owing to the numerous creeks and low-lying land on their banks. The area drained by the Stamford Canal is an exception in this respect, because this waterway has been sluiced at its junction with the sea, and it has been converted into an open masonry storm-water channel. Similarly, that portion of Singapore near the mouth of the Singapore River is also an exception, owing to the banks and land adjacent having been raised at an early period to form the boat quay.

The soil varies in character, but chiefly consists of clay ironstone or laterite, or sand, or a mixture of these with outcrops of granite, sandstone, shale and conglomerate.

4. Climate.

Situated in latitude 1–17 North, or less than $1\frac{1}{2}$ degrees from the Equator, Singapore has all the characteristics of an equatorial climate in which it is always summer. There are no distinct seasons, and its mean annual rainfall, which is distributed in every month throughout the year, is 95 inches ; some months have more cloudy and rainy days than others, and in these the days are cooler, but the difference between the mean temperature of the cooler months and that of the hotter months is not more than 4° F., while the range between the maximum and minimum temperature in any one month is seldom more than 14°, the annual mean being well under this figure. Occasionally there is a year in which the temperature is maintained at a considerably higher level than usual, and the range is greater, but on the whole the principal feature of the climate is its uniformity. The nights are generally comparatively cool, a sea breeze tempering the heat ; sometimes there are calms, and then the air is oppressively hot.

The annual mean temperature of 79° to 80° F., or in some years even higher, conveys very little conception of the kind of climate, except it be its monotony. It is not as high as many of the more northern countries

within and beyond the tropics during the hot season, but in Singapore the high temperature, such as it is, is constant. There is very little variation and the moisture in the atmosphere is also more constant and greater, the mean relative humidity being 80 per cent. It is this moisture, combined with a continuously high temperature, that is trying to most Europeans. The moist heat suits some constitutions while others become acclimatised, but with the remainder, that is with the majority, it is a struggle to resist its debilitating effect for any considerable time without a change to a hill station or to a cooler climate. When insanitary surroundings detrimental to health are also associated with such a climate as described, the susceptibility to disease thereby engendered becomes particularly strong. That very insanitary conditions exist in Singapore will be shown later on.

POPULATION AND VITAL STATISTICS.

5
Population.

The population of Singapore, which is a very heterogeneous one, was at the census of 1901, 207,431, of which, approximately, over 72 per cent. were Chinese, 14 per cent. Malays and other natives of the Archipelago, and 7 per cent. Tamils and other natives of India. The remaining small percentage consisted of Europeans, Americans, Eurasians and other races, including Arabs, Armenians, Siamese, Singhalese and Japanese. Of the 2,750 resident Europeans and Americans, 878, or over 30 per cent., were non-British, and of that 30 per cent. 407, or 46 per cent., were Germans and Dutch.

Between the census of 1891 and 1901, the population increased over 47,000, or, if the floating population is deducted, 37,000. This increase was not due to a preponderance of births over deaths. The average annual birth-rate for the ten years was only 16·70, whereas the death-rate was 39·23, *i.e.*, the deaths for the ten years were more than twice the births. If the four years after the last census be taken the number of births in 1902, 1903, 1904 and 1905 was respectively 4,098, 4,259, 4,958, 5,129, making a total of 18,444, while the number of deaths in the same years was 10,860, 10,257, 9,893, 9,901, equal to 40,931, *i.e.*, there were 40,931 deaths in the four years against 18,444 births. The comparatively low birth-rate is partly explained by the difference in the relative ratio of the sexes, and partly by the large number unmarried. There are in Singapore three males to every female. In the Chinese community there are four males to every female, and a similar ratio holds with regard to the natives of India. The Malays are the only large community which forms an exception. Among them the ratio is nearer equality, but as they only form 14 per cent. of the population their prolificness is but a comparatively small factor in the maintenance and increase of the population as a whole. Even their birth-rate of 32 to 35 per 1,000, increasing within recent years to 44 and 45, with better registration, will count but little when 35 to 45 per cent. of the infants born die before they reach one year of age. This high infantile mortality is not confined to the Malays, it is common to the other races, Europeans excepted.

The maintenance and increase of the population are principally due to a constant influx of people from China, India and the Malayan Archipelago, who replace those who die or leave the town. Approximately, there are about 200,000 immigrants landed annually in Singapore, but how many of these remain in Singapore it is impossible to tell. No records of emigrants are kept, and it would, under the circumstances, be impossible to keep accurate records. Though a considerable proportion of the numbers remain, yet the majority go elsewhere to supply labour for the Malay States, Java, Borneo and other neighbouring countries.

6. Death-rate.

The peculiar situation of Singapore in this respect makes it difficult for the Health Officer to give a satisfactory estimate of the annual increases of population between the decennial censuses, and this necessarily affects the value of the vital statistics presented. Dr. Middleton's recommendation, that there should be a quinquennial census, is a sound one and thoroughly in the interests of Singapore, where it is of the highest importance that any considerable under-estimation or over-estimation of the population should be detected. In the one case, the death-rate appears to be higher than it is, and, in the other, lower. A ten years' interval before the estimates can be checked is too long. The average death-rate calculated on the basis of the two last censuses is a high one :—

DEATH-RATE FROM 1892–1905.

1892.	1893.	1894.	1895.	1896.	1897.	1898.
31·27	36·19	32·31	44·67	48·66	42·10	36·14
1899.	**1900.**	**1901.**	**1902.**	**1903.**	**1904.**	**1905.**
36·21	43·57	45·25	57·11	47·25	44·62	43·74

Possibly during the first few years the registration of deaths was not so complete as it is now, which may account for the smaller death-rate in the early period, but even assuming this to be so, and that there has been no retrogression, the figures indicate that the health of Singapore is not improving, and that the forces of destruction are at least as powerful as any agencies of an opposing nature brought into play by the Municipality for preventing or checking their action. In other words, the sanitary measures taken by the Municipality have not been sufficient to reduce the high death-rate of the town.

The high death-rate, notwithstanding the low birth-rate, is specially significant. It means that although there is proportionately a small number of infants and children in Singapore, among whom in all communities the death-rate is highest, yet in Singapore, even with this advantage, the death-rate is abnormally high. The effect on the general death-rate of an excessive infantile mortality following a low birth-rate is necessarily smaller than that resulting from a high birth-rate with a similar infantile mortality. So that in Singapore there is an excessive adult mortality as well as an excessive infantile mortality. If the

character of the adult population be considered, then its high mortality becomes even more serious. It is essentially a population at the most vigorous period of life, viz., between fifteen and fifty-five years of age, with very few above the latter age. Just as the ratio of infants is small, so is that of old people. The two extremes of life at which the mortality is always highest are far from being absent, but they form only a small proportion of the population of Singapore. The age constitution is such that there should be a low mortality. Another element which should tend to keep the death-rate low is the initial physical condition of the people. If the natives of India be excluded, the other races are noticeably of a fine physique, and particularly is this the case with the Chinese, who form the largest portion of the community. I have had the opportunity of examining the Chinese immigrants as they arrive by ship, and it may be stated that, with some exceptions, they represent physically an uncommonly fine body of adults. This fine physique is an invaluable asset to draw on for the maintenance of health. A high death-rate with such a population means an extraordinary death-rate.

Causes of disease and Registration of deaths.

In determining the causes of death which make up the high death-rate, not much precise information is to be obtained from the death statistics. The reasons for this are, firstly, that very few who are ill are attended by a qualified medical man. Only about a quarter of the deaths are certified by qualified medical men; and, secondly, the causes of death, as now recorded, are the conclusions arrived at by an inspector trained in one of the medical colleges of the East, who is sent to view the body and make enquiries after the death has been reported.

The method adopted of ascertaining the cause of death by medical inspection and inquiry after death is most useful for medico-legal or police purposes, and is certainly a wholesome check on crime. It is not so satisfactory in affording adequate or accurate information to the Health Authorities in regard to the prevalence of diseases general and epidemic. But, in the absence of medical certificates, it is a substitute which cannot be dispensed with. It might nevertheless be improved, for, unsatisfactory as it is, it is rendered more so on those occasions when it is of the highest importance to the public weal that the information should be of a more precise character. Such an occasion occurs when the Medical Inspector, either from the circumstances of the case, or from a suspicion that the death is due to a dangerous or infectious disease, is unable to form an opinion as to the probable cause of death. Then the only possible method of removing the doubt and ascertaining the actual cause of death is by an autopsy. Under existing arrangements the case is first submitted to the Coroner, who by the same methods as those adopted by the Inspector has to undertake to solve a medical problem which has already been pronounced by a medical man to be a perplexing one. It is not solved, for over 92 per cent. of the cases thus submitted during the first months of 1906 had the cause of death returned as "natural causes," and the remainder were sent for autopsy.

It would be more to the interest of the public, if, when the Medical Inspector is unable to certify the cause of death, the Health Officer were empowered to depute one of the Assistant Health Officers to see the body and make enquiries, and on his report either to give a certificate of death or order an autopsy. The report of the cause of death should be immediately forwarded to the Registrar, and in cases of suspicion of foul play to the Coroner. Whatever action may be taken to improve the methods for ascertaining the causes of death it is essential that the existing extremely primitive and unsanitary arrangements connected with autopsies should be abolished and replaced by a well-equipped mortuary, laboratory and an organised staff.

8. Method of improving registration.

Registration both of births and deaths could also be improved by adopting the system of dispensaries, introduced with such excellent results into Bombay by Dr. Turner, the Health Officer. In such registration districts there is a dispensary and the Medical Officer is also the Assistant Registrar. Patients from the district come to the dispensary and are attended free, their names, addresses and cause of sickness being recorded. Some are seen at their homes. In this way a very fair knowledge of the kind of sickness prevailing and its extent is obtained from the district, which is of much assistance to the Assistant Registrar in determining the cause of death before registration.

There is attached also to the dispensary a qualified midwife, who attends poor women in their confinement, and who teaches them cleanliness and the management and care of their infants. At the same time she learns about the births in the district, sees that they are registered, and, by her visits, exercises a very important influence on the mothers in the proper feeding of their infants. Since the midwife has been at work registration of births has much improved.

The value of the system is that it gives to the Health Officer information not only of the causes of death of each district, but also keeps him cognisant of the causes of prevalent sickness. It also enables him to deal with the unhygienic conditions and practices which conduce to a high infantile mortality.

There would be no difficulty in introducing a similar system into Singapore now that the Chinese Medical School has been established, where medical men and midwives can be thoroughly trained. It would be an outdoor extension of the Government hospital system. In Bombay the dispensaries are municipal, and are instrumental in spreading the rudiments of hygiene among some of the poorest inhabitants.

Instructions for rearing the child.

I would further suggest that at the time of the birth of the child a leaflet should be given by the Registrar, printed in the language of the parent, with a few simple rules on the management of the child and what to avoid. Another leaflet might again be given when the child is vaccinated.

The following table clearly shows the high death-rate of Singapore and the general characters of the diseases recorded, which principally make up that death-rate.

9. Principal class of diseases making up death-rate.

STATEMENT OF THE NUMBER OF DEATHS FROM THE PRINCIPAL DISEASES DURING THE FIVE YEARS 1901–1905.

Year	1901.	1902.	1903.	1904.	1905.	1901–1905.	
Mean Annual Population estimated from the Censuses ...	207,431	212,448	217,070	221,692	226,314	216,991	
Small-pox	12	53	30	9	11	115	
Plague	14	3	3	18	19	57	
Diphtheria	9	6	3	7	4	29	
Cholera	120	737	184	3	15	1,059	6,003
Enteric Fever	54	218	64	70	95	501	
Dysentery	241	240	323	289	377	1,469	
Diarrhœa, Dysenteric Diarrhœa, Choleraic Diarrhœa	358	403	499	363	369	1,992	
Gastro-enteritis, Bowel complaints	247	237	172	144	182	982	
Tubercular Diseases ...	1,700	1,831	1,600	1,533	1,852	8,516	12,301
Respiratory Diseases ...	606	552	766	808	1,053	3,785	
Beri-beri	1,319	1,065	1,301	1,538	1,163	6,386	
Remittent Fevers and Malarial Diseases ...	1,749	2,131	1,569	1,693	503	7,645	
Other Fevers, not including Enteric ...	73	194	463	532	977	2,239	
Other Diseases ...	2,886	3,190	3,280	2,889	3,281	15,526	
TOTAL	9,388	10,860	10,257	9,896	9,901	50,302	
Death-rate per 1,000 of population	45·25	51·11	47·25	44·62	43·74	46·36	

A quinquennial average general death-rate of 46 per 1,000, of which bowel complaints, lung diseases and beri-beri constitute over 20 per 1,000, points to a condition of things which is obviously bad.

The general classification of the causes of death receives a certain degree of confirmation from the 906 autopsies performed during the year 1905 at the Tan Tock Seng Hospital. Of the 906 examinations made by Dr. Finlayson, the Government Pathologist, and which represent nearly one-tenth of the deaths in the town in the year, 19 per cent. appears to have been due to beri-beri, 17·6 per cent. to tuberculosis, 17 per cent. to dysentery, and 11 per cent. to malaria.

Comparing these results with those obtained from the registers for 1905, and for the quinquennium, the percentages stand as follows :—

	Autopsies in 1905.	Registered Deaths for 1905.	Registered Deaths for the Quinquennium.
Cause of Death.	Percentages.	Percentages.	Percentages.
Beri-beri	19	11	12
Tuberculosis	17·6	18	16
Dysentery	17	Bowel complaints, including Dysentery, 10	11·6
Malaria	11	5	13
Respiratory and Tubercular diseases combined ...	24	29	24

It will be seen that there is little difference in the percentages of tuberculosis, and this holds good when tubercular and respiratory affections are combined. This class of diseases is likely to be more correctly diagnosed from their history than the others.

Bowel complaints as a class should also be more readily recognised, but if the moiety of deaths in which the cause has been accurately ascertained be taken as a standard, it is apparent that the death-rate from dysentery recorded in the registers is very much below the mark. It will be observed that 17 per cent. of the 906 cases examined was from dysentery alone, whereas when from the registers the deaths from all bowel complaints are added together, even including enteric fever and cholera, the percentage is only 11·6 at the highest, and for dysentery alone less than three.

Tuberculosis.

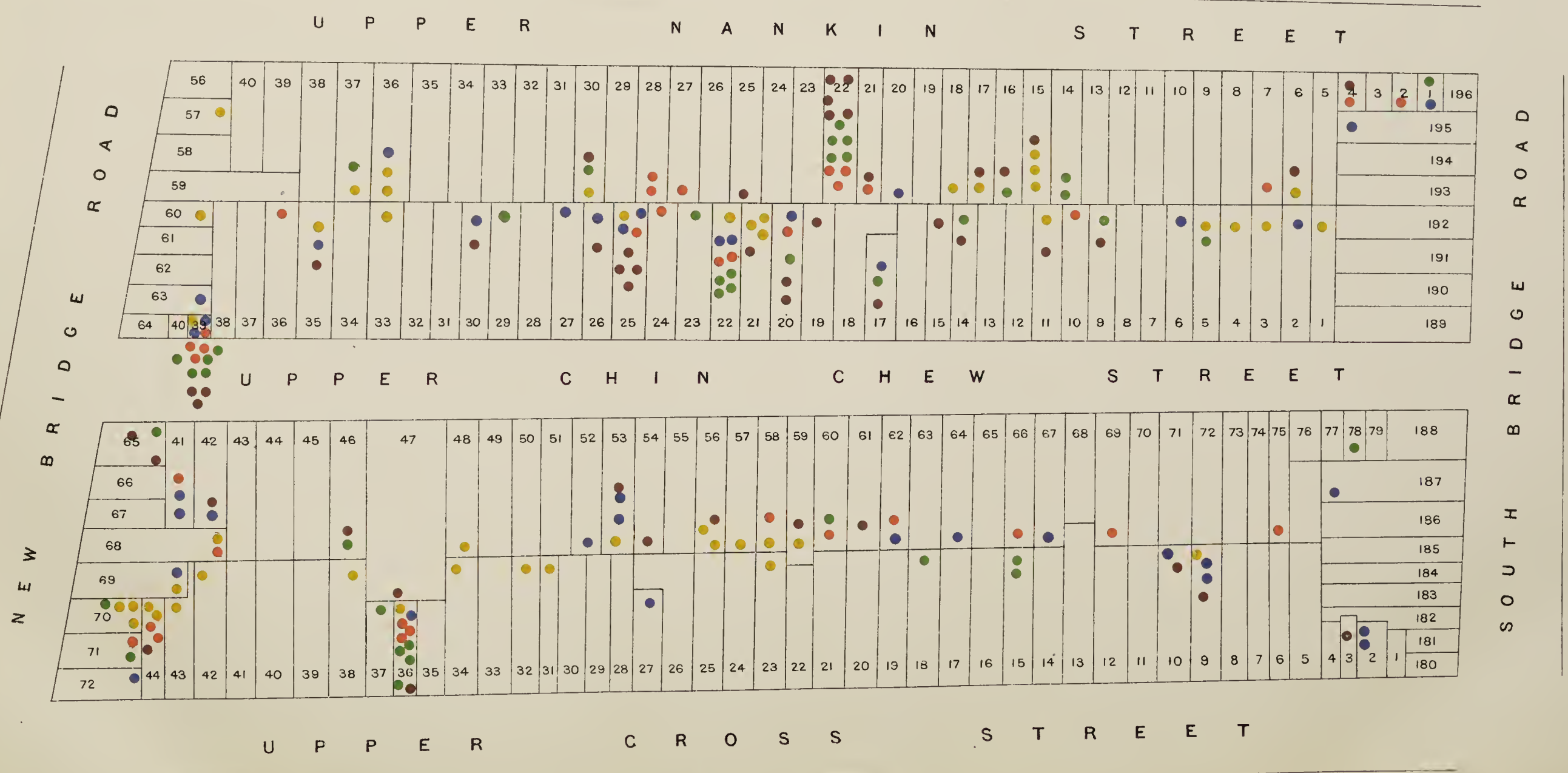
Dr. Freer has furnished me with a tabular statement (Appendix A, page 124) comparing the proportion of tubercular diseases treated in 1893 in the General Hospital, when he was House Surgeon there, with that of the last twelve months. The result is that the percentages to the total admission have increased nearly three times in the Native Wards, have declined in the European Wards, and remain much the same in the Native Police Wards.

Diagram I. shows the number of deaths recorded in five years from tuberculosis in two blocks of houses. The number does not include deaths from this cause occurring in hospitals the addresses of which are not obtainable, nor of many other registered deaths from the same cause but of which no addresses are given. The plan, nevertheless, very graphically illustrates the great incidence of the disease in houses of a class which are numerous in the town, and the condition of which will be described later on. The disease once in a house tends to recur, some years being worse than others, until it almost assumes an epidemic form. The conditions as regards light and air in a house that are favourable to phthisis are also those which are favourable to plague, whenever this disease acquires a firm hold in a town.

Tuberculosis should be treated as an infectious disease, and should be notified when attended by a medical practitioner, in order that the

DIAGRAM I.

DEATHS FROM TUBERCULOSIS



WATERLOW & SONS, LIMITED, LONDON WALL, LONDON

house may be inspected and disinfected. In the case of tubercular deaths being registered, the same action should be taken, viz., inspection and disinfection of the house.

A death-rate of 8 per 1,000 for tuberculosis and 11 per 1,000 for respiratory and tubercular diseases at once direct attention to the housing conditions, and it is with these we shall first deal.

HOUSING CONDITIONS.

10. Housing conditions in Singapore.

Singapore impresses one with its extent, spaciousness and beauty generally; it is laid out with wide streets crossing at right angles to one another. For this arrangement it is indebted to Sir Stamford Raffles, its great and far-seeing founder. As early as 1822 he appointed a committee to plan out the site of the town, arrange the European and Native divisions, and deal with the proper allotment of lands. He also wrote a minute for the guidance of the committee, in which he set forth his views as to the arrangement of the streets, warehouses, public buildings, &c. Accordingly, there are not the narrow streets and winding lanes which are to be found in many of the towns of the East. Most of its houses are two stories, and as there are numerous open spaces unbuilt on, and several recreation grounds, and much open space attached to the European houses and also to the wealthier native houses the town with its suburbs covers an extensive area. The openness of this area is increased by the number and extent of old Chinese burial grounds situated on some of the hills and high ground, and which occupy some of the best sites in the town. The fact of the dead occupying the high ground while the living are dwelling on the adjacent low swampy ground strikes one as being very remarkable.

11. Crowding together of buildings.

There is very little indication from the general appearance of the town that *over-crowding of area by buildings* is an important factor in its unhealthiness. The blocks of houses, and the houses themselves, have to be visited before such a conclusion is possible. It then becomes evident enough that though the houses that have been erected have ample street space, they are crowded together on the area of land to such an extent as to render them unhealthy. This more particularly applies to the Chinese quarters, and to the Chinese houses in other quarters of the town. The distribution of the Chinese population is such that more than one half lives on the south side of the Singapore river, the greater portion being concentrated near its banks; the other half is on the north of the river, but much more scattered over a wider area, the greatest concentration being near the Rochore River on its southern side. The Chinese, however, forming over 70 per cent. of the population, are to be found more or less everywhere, and their style of building is noticeable wherever they settle. Hence the evils which the particular design of house building gives rise to where the Chinese are located in numbers is also to be noted to extend in a lesser degree to quarters occupied chiefly by other races, whose houses are of a different type, but where the Chinaman is allowed to build.

12. The Chinese mode of house building.

The Chinese prefer, when possible, to build horizontally rather than vertically. The simplest house consists of two single storied huts or buildings placed one behind the other, but separated by a courtyard, the hut or building in the rear having a courtyard behind for domestic purposes.

Enlargement of the house is not effected by adding another storey to heighten it, but by erecting another building behind, also separated by a courtyard. There may thus be a series of buildings each with courtyards approached by passages leading one from the other. This mode of building is a very convenient one where the space is not limited, and some houses may, in this way, attain a great depth.

In Singapore, with its rectangular blocks, the Chinese have adopted this style of building as far as it was possible, but when horizontal building was obstructed at the rear by coming, as it must, sooner or later, in contact with similar additions made to the house immediately at its back, but which faces the next street of the block, one or other of two alternatives presented itself to the owner. The first was to build vertically and contract the courtyards, and the second was to acquire the property behind and get a communication right through to the other street. Sometimes both plans were adopted.

Vertical building, under these conditions, tends, when carried beyond a certain point, to bring about a very unhealthy condition of affairs.

The general results of this combination of Chinese and European methods of building is that, on the south side of the river, which is essentially the Chinese quarter, both narrow and wide blocks are filled up, and packed with buildings, which, in the narrow blocks, form back-to-back houses, and, in the wider blocks, congeries of buildings abutting one upon another.

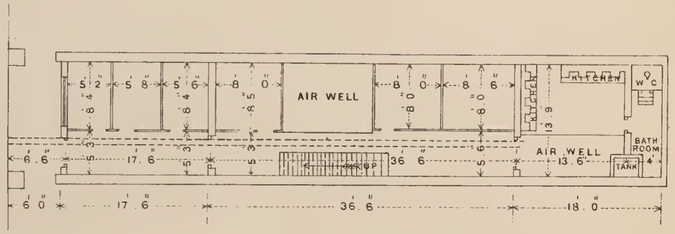
This state of affairs is absolutely destructive to healthy lighting and ventilating of the houses, and to efficient scavenging and drainage of the houses in the blocks. Fortunately for Singapore, the blocks on the northern side of the river have not been affected to the same extent, and, though there are signs in many places of the same evils spreading to them, yet, for most of them, there is time, by the adoption of proper building laws and regulations, and their rigorous administration, to arrest and prevent the wholesale creation of insanitary areas which has been permitted on the southern side.

13. Illustration

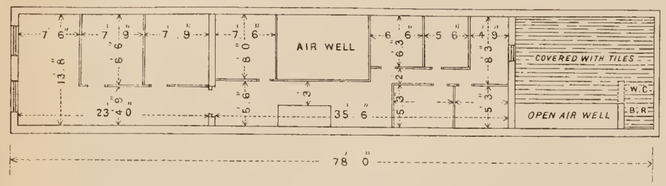
Examples of the different stages through which the buildings pass are to be seen almost in every street. Some of the older houses have only been slightly altered, while others have been changed to such an extent as to appear totally different from the others. There are two-storied houses, 40 ft. in depth, with a good back yard of 30 to 40 ft., and separated from their neighbours by a wall of 7 or 8 ft. in height. There are other similar houses in which the back yard has been partially covered over with a tiled roof at the sides and at the back, leaving a courtyard open to the sky measuring 15 to 20 or more feet from back to front, and

PLANS OF 2 STORIED HOUSES.

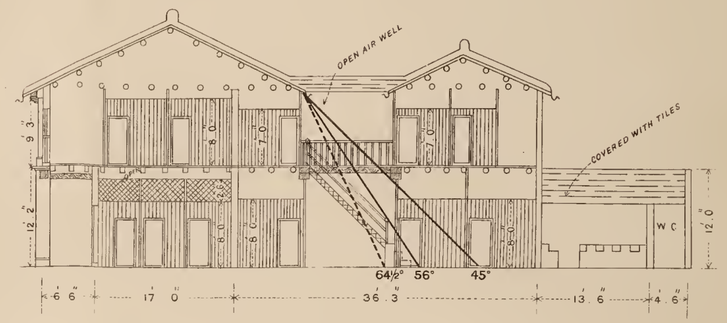
PLAN III.



GROUND PLAN

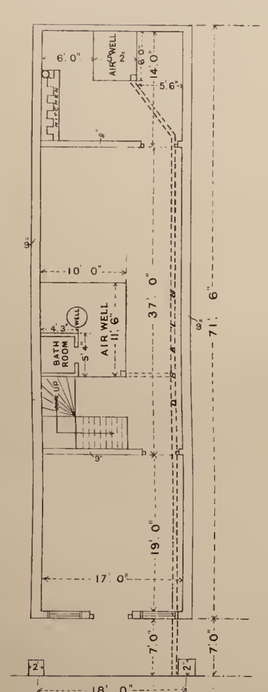


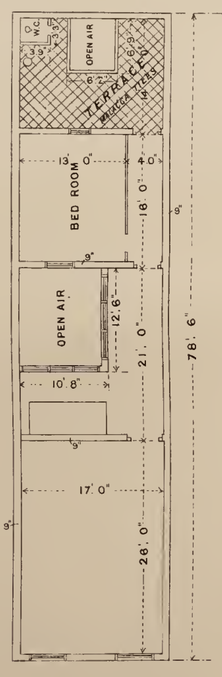
FLOOR PLAN



LONGITUDINAL SECTION

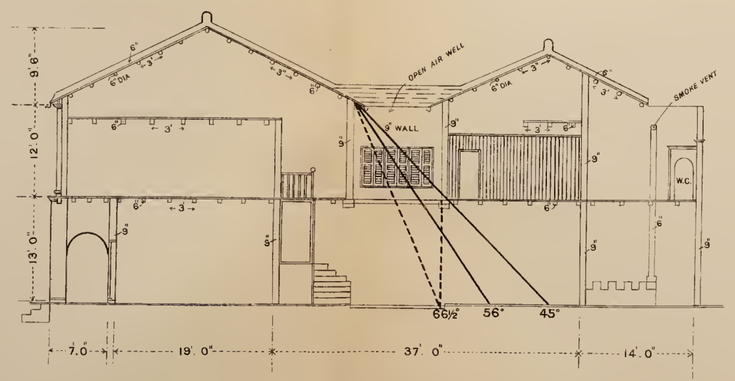
Nº 20 UPPER NANKIN STREET.





GROUND PLAN. FLOOR PLAN.

PLAN II.

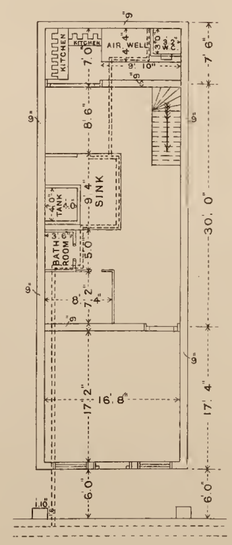


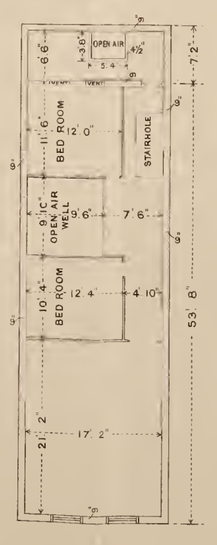
LONGITUDINAL SECTION

Thick dotted line indicates existing angle for open space.

Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

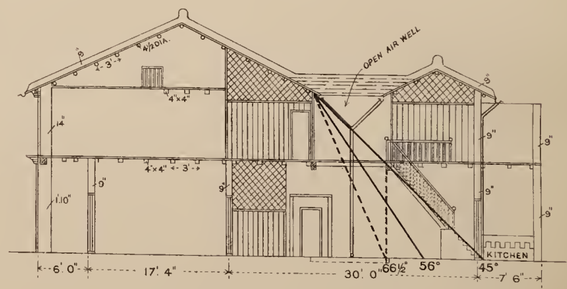
Nº 35 UPPER NANKIN STREET.





GROUND PLAN. FLOOR PLAN.

PLAN I.



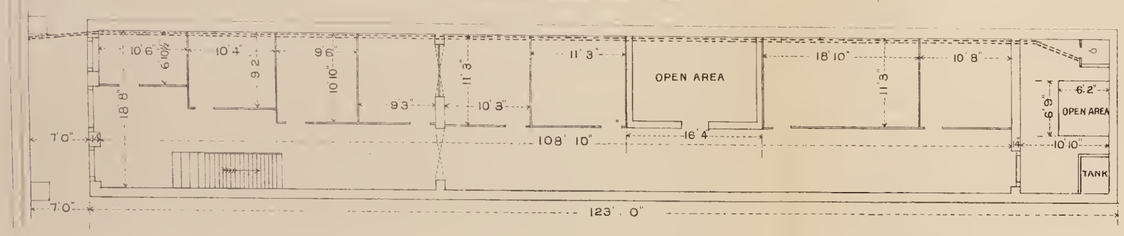
LONGITUDINAL SECTION

Nº 48 UPPER NANKIN STREET.

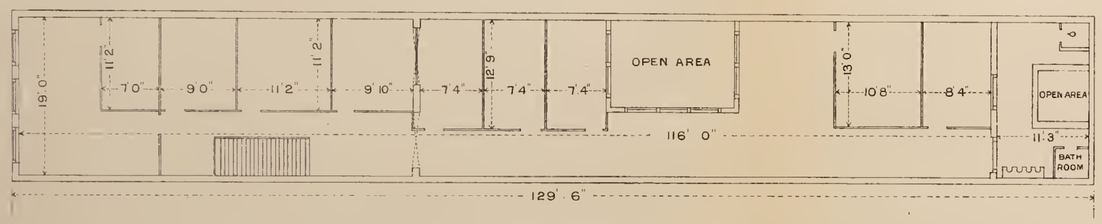
WATERLOW & SONS LIMITED. LONDON WALL LONDON

PLANS OF 2 STORIED HOUSES.

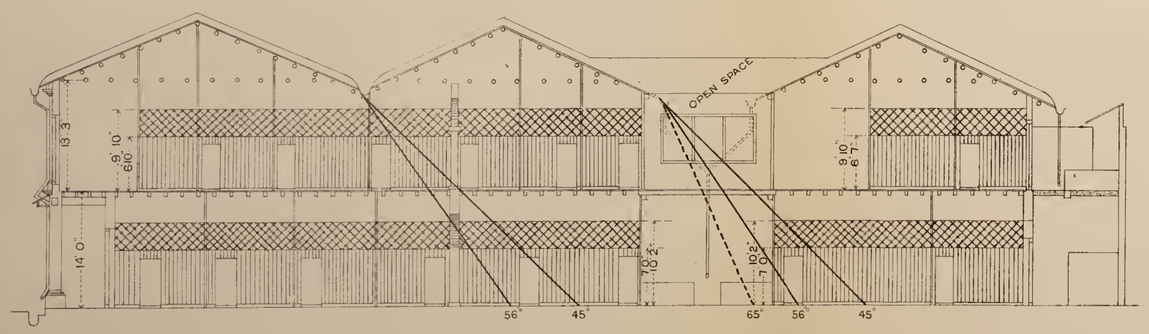
PLAN IV.



GROUND PLAN.

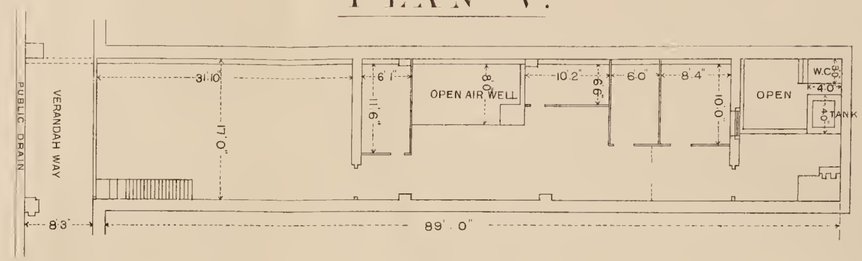


FLOOR PLAN.

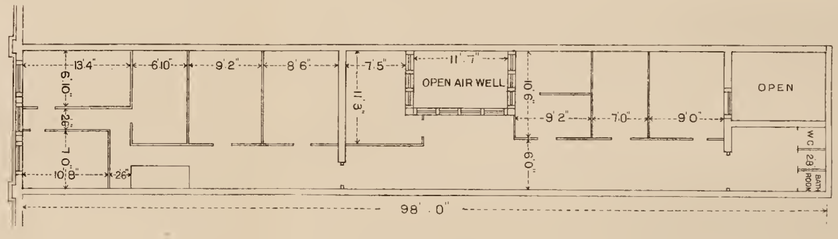


LONGITUDINAL SECTION.

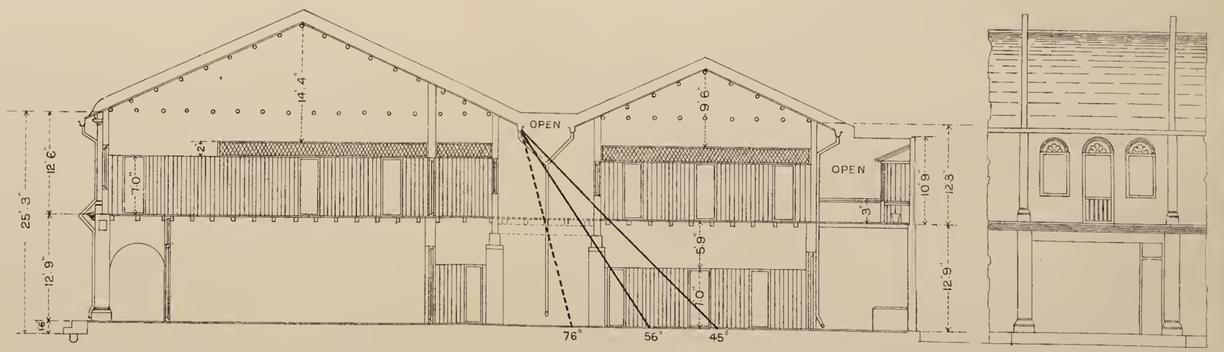
PLAN V.



GROUND FLOOR.



FLOOR PLAN.



LONGITUDINAL SECTION.

ELEVATION

Thick dotted line indicates existing angle for open space.

Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

Nº 157 CECIL STREET.

Nº 32 NORTH CANAL ROAD.

WATERLOW & SONS LIMITED LONDON WALL, LONDON.

from 7 to 10 ft. in width, the total width of the house varying from 16 to 18 ft. Behind this tiled roof at the back, and between it and the wall of the premises of the house at the back, is occasionally seen another open space, some 4 or 5 ft. in width, which is now usually occupied by a latrine, but which has the appearance at times of the remnants of a narrow back lane between the rears of the houses, but which, in course of time, has been appropriated and built on. There are other houses in which this roofing-over of the back yard has been increased, and the one storey has been raised to two stories, and the walls to a corresponding height. Even in these instances the courtyard may be spacious, and only the ground floor at the back of the house suffers from insufficient light and ventilation.

14. Private houses.

The type of the better class houses of two stories in some of these blocks is represented by Plans I. and II., occupied by a single family. The house covers an area of 70 to 80, or perhaps 90, ft. in depth, and 16 to 18 or 20 ft. in width. A verandahed central courtyard divides the front from the back part of the house, and a small back yard, with a high wall, separates this from a similar house in its rear or on either side. The house has no living rooms below except the front room. The courtyard is used as a general place for domestic purposes in connection with bathing and preparing food for the kitchen, which is in the back area. The latrine is also at the back, and the drainage from latrine, cook house and bathing place enters a surface drain covered with planks, and, passing through the house from back to front, discharges into the surface drain of the street.

The objections to the house are, first, its darkness at the back on the lower floor; secondly, the passage of the drainage through the house and nuisance arising from such an arrangement; and, thirdly, the impossibility of emptying the latrine except by the coolie entering the house and carrying the nightsoil through the front door.

15. Tenement houses.

Plan III. represents the same kind of house converted into a tenement house. The lower floor is subdivided into dark and ill-ventilated cubicles, each of which is used as a living room by one or more inmates. The same kitchen, latrine and drainage arrangements are provided downstairs as in the private house, but as they are used by more people, and the back yard is darker, the nuisance from them, especially from the latrine and drainage, is more pronounced. The second storey is also subdivided into cubicles. The only room with sufficient light is the front room. This, in the particular house represented by the plan, was found, on inspection, to be used as a schoolroom, in which a Chinese schoolmaster was teaching ten children. The fee for each child was a dollar and one half a month.

Plan IV. represents another tenement house two stories in height. Here the building is 129 ft. in depth and 19 ft. in width, and a second building has been added directly on to the front building without an intervening courtyard, and a third building separated from the second by a courtyard.

It is also subdivided on both floors into a large number of cubicle rooms, each containing one or more persons. The doors of the cubicle rooms are seen in section, and the trellis work above shows the arrangement intended to give them a sufficiency of light and air. As a matter of fact it does neither. The house has no lateral windows and the cubicles are windowless rooms, dark and cheerless, receiving neither light nor air direct from the outside.

Behind this house is one of the few back lanes now existing in Singapore, but it brings no light or fresh air into the rooms. The design of the house without the cubicles is sufficient to make this an impossibility.

16. Shop-houses.

Plan V. represents a two-storied house in which the front room is converted into a shop and the back premises into dark cubicles. In the better class shops the staircase still remains and the family live upstairs, but in the type shown on the plan, which is the most common type of the shop house, the central staircase is removed and placed at the side and front of the shop, a portion of the shop being boarded off to provide space for the staircase. The second storey can then be reached from the front street, and is sublet to a tenant, who proceeds to subdivide it into cubicles or windowless rooms and sublets them. This design of house is often adopted in new buildings. The majority, however, are old buildings that have been altered in the manner described, and the process is seen to be going on in street after street. In some instances in which the block is wide enough to permit of more than two buildings, one behind the other, as in Church Street, sometimes the central staircase is kept for the front building and a passage is made at the side and at the expense of the shop space for access to the buildings behind, thus obviating the inconvenience that would arise from the occupants of the back premises passing through the shop. The process of subdivision goes on even in the shops. Sometimes a board will be so erected as to divide into two shops what originally was one.

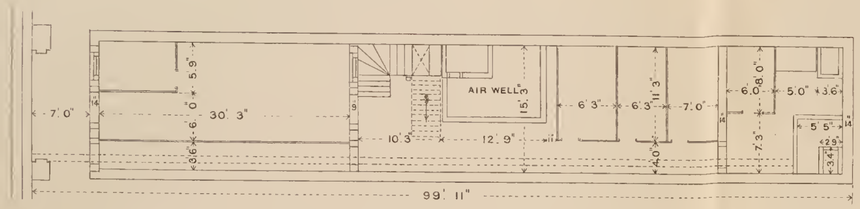
Plans VI. and VII. represent three-storied shop-houses. They are subdivided into floors, and each floor is subdivided into cubicles occupied by a family in each. Each floor has its kitchen arrangements, latrine, and generally its bathroom.

The coolie has to enter each floor to empty the contents of the latrine pails. In the case of the lower floor he has to convey the nightsoil through the shop, and in the case of the second and third floors down the front stairs. As the latrine pails are washed on the premises, the washings pass from the upper storey to the lower and enter the surface drain along with the washings from the latrine on the lower storey, and flow through the shop to discharge into the surface drain in the street. It is the same with the sulliage and refuse from the different stories. The unsanitary condition of the interior of the house is intensified by the absence of daylight, which the design and arrangements of the house effectually occlude.

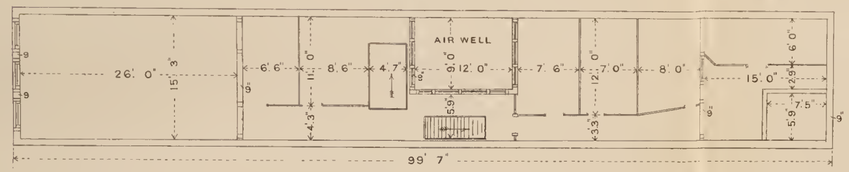
Plans VIII. and IX. represent respectively a three-storied shop-house and a three-storied tenement house. The only difference between

PLANS OF 3 STORIED SHOP HOUSES.

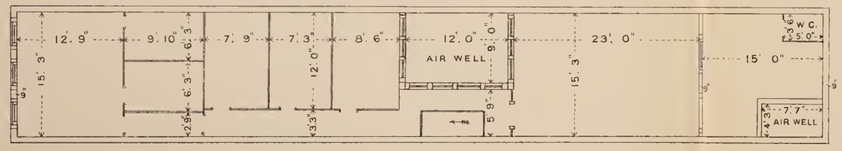
PLAN VI



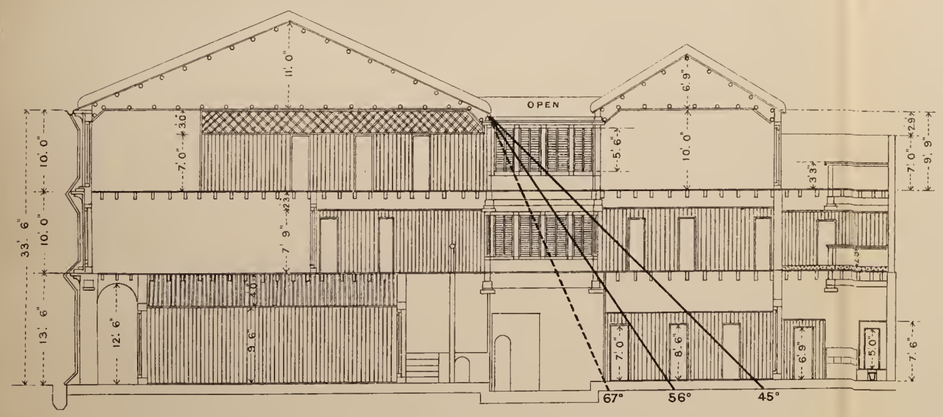
GROUND PLAN.



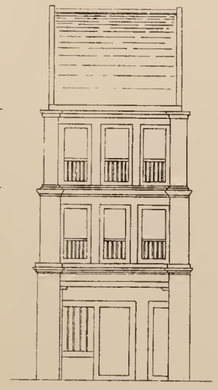
FIRST FLOOR.



SECOND FLOOR.



LONGITUDINAL SECTION.



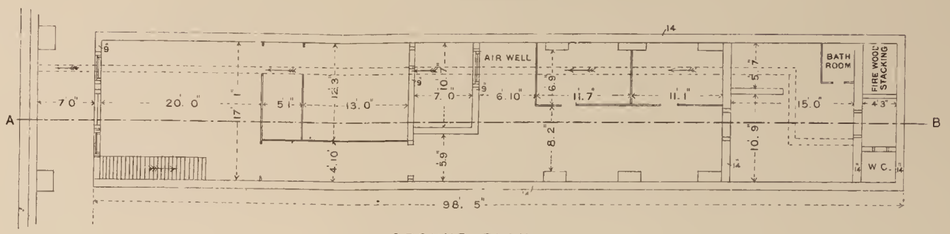
FRONT ELEVATION.

No. 1 PEKIN STREET.

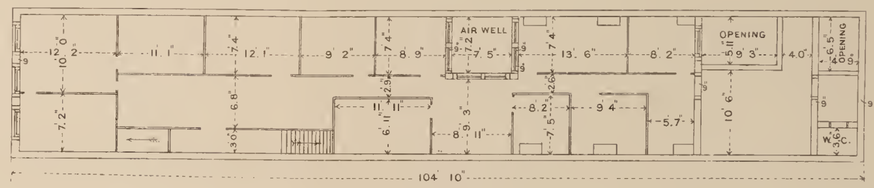
Thick dotted line indicates existing angle for open space.

Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

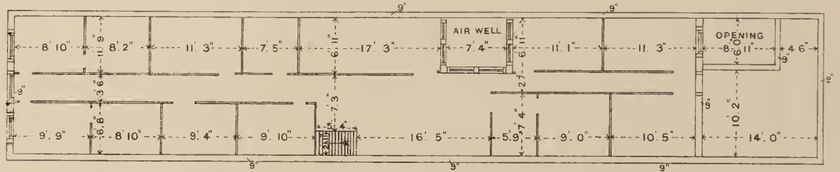
PLAN VII



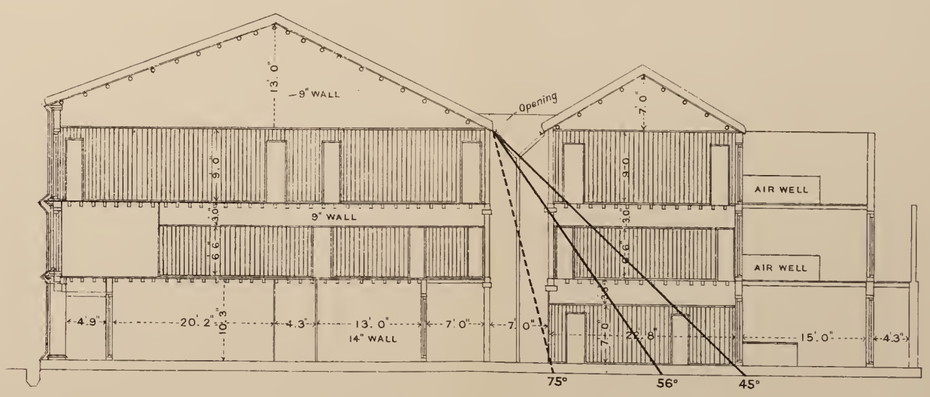
GROUND PLAN.



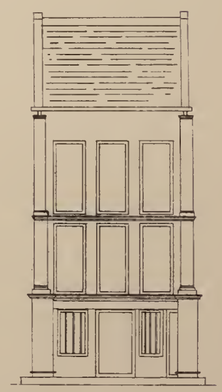
FIRST FLOOR



SECOND FLOOR.



LONGITUDINAL SECTION. A.B.

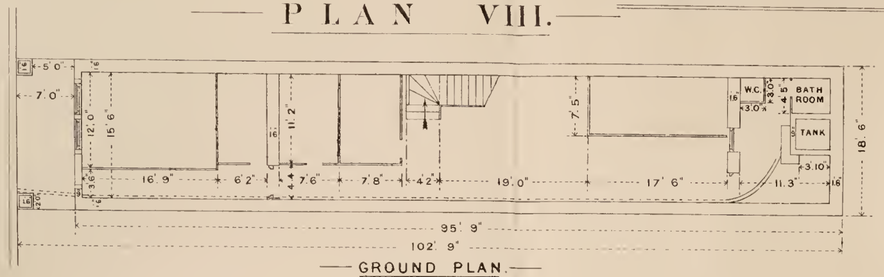


FRONT ELEVATION.

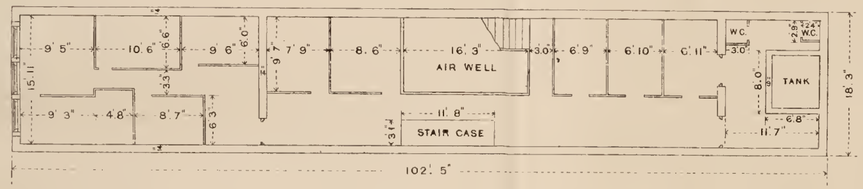
No. 38 HONG KONG STREET.

PLANS OF 3 STORIED HOUSES.

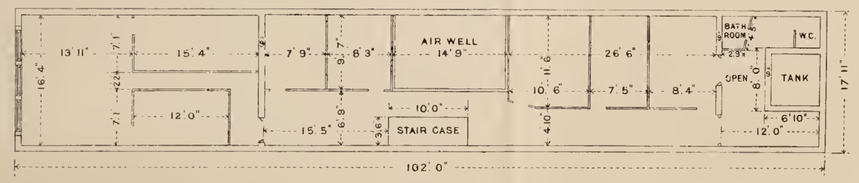
PLAN VIII.



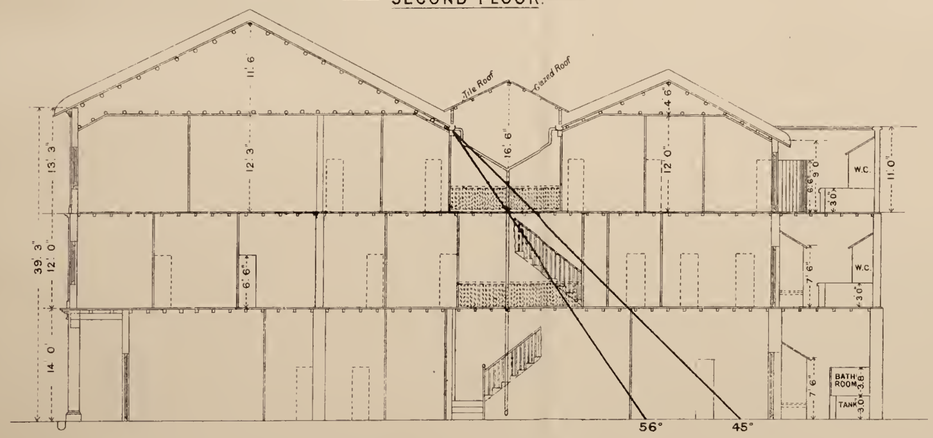
GROUND PLAN.



FIRST FLOOR.

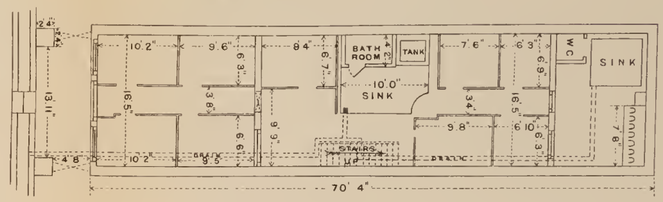


SECOND FLOOR.

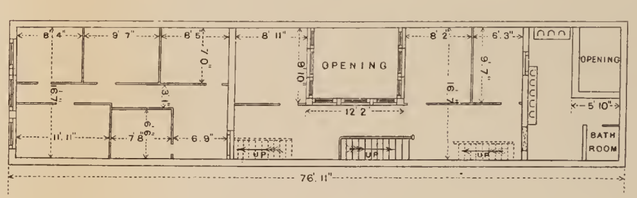


LONGITUDINAL SECTION.

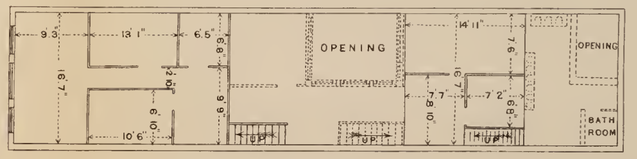
PLAN IX.



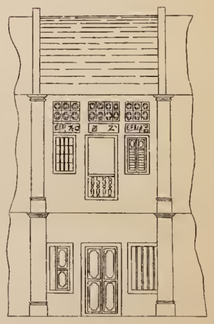
GROUND PLAN.



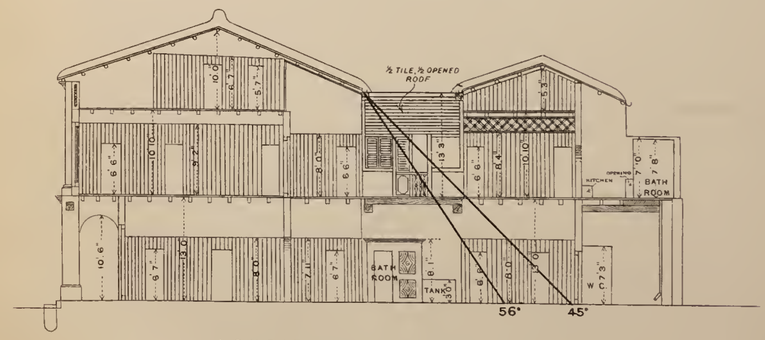
FIRST FLOOR.



SECOND FLOOR.



FRONT ELEVATION.



LONGITUDINAL SECTION.

Nº 24 JAPAN STREET, WITH AIR WELL COVERED OVER.

Nº 18 UPPER CHIN CHEW ST., WITH AIR WELL PARTIALLY COVERED OVER.

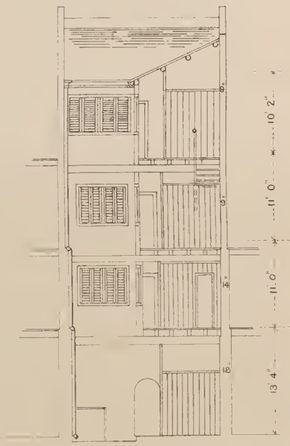
Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

WATERLOW & SONS LIMITED, LONDON WALL, LONDON.

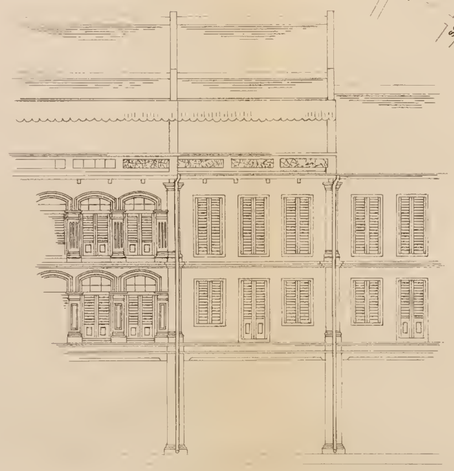
PLAN OF A 4 STORIED HOUSE

Nº 18, SAGO LANE AND Nº 20-3 SAGO STREET.

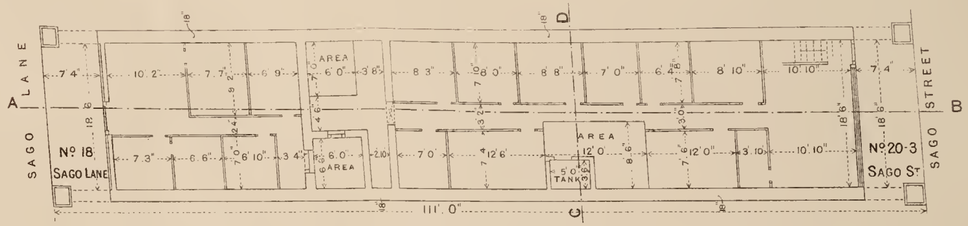
PLAN X



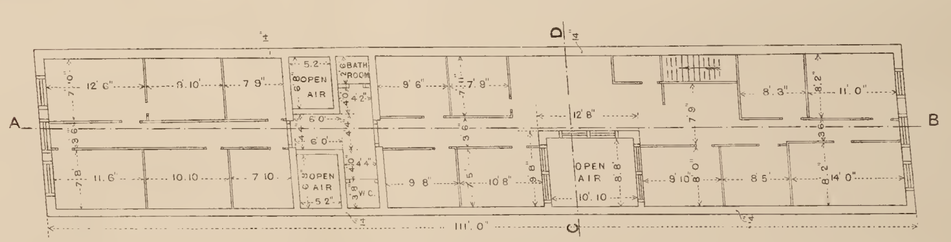
CROSS SECTION



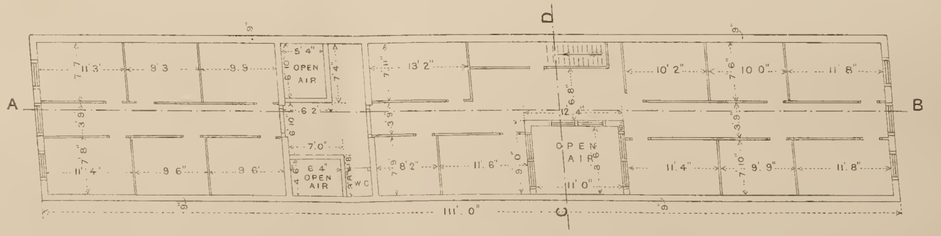
ELEVATION AT SAGO ST



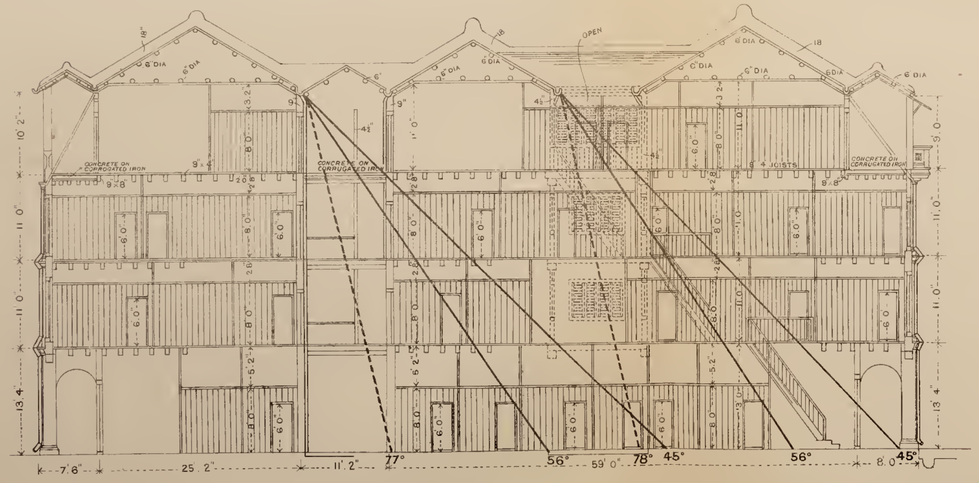
GROUND FLOOR.



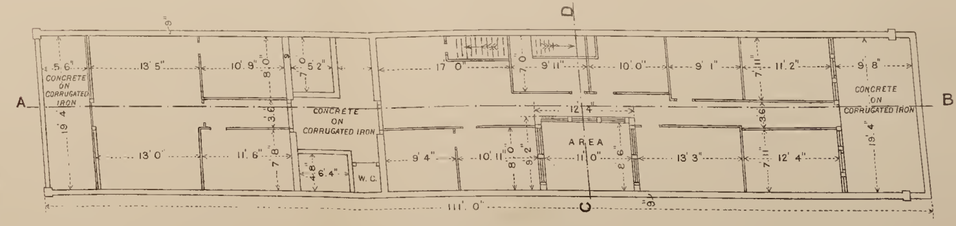
FIRST FLOOR.



SECOND FLOOR.



LONGITUDINAL SECTION.



THIRD FLOOR.

Thick dotted line indicates existing angle for open space.

Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

WATERLOW & SONS LIMITED, LONDON WALL, LONDON

them is that the shop-house has a shop, and possibly a warehouse, on its lower floor, but both kinds of houses are tenement houses. They are sub-divided into floors, and each floor is sub-divided again into cubicles occupied by one or more persons in each, just in the same way as has been described as happening in the two-storied houses. Most shop-houses, whether two or three stories, are tenement houses.

The deterioration of the house with its deprivation of light and air has advanced a stage further in Plans VIII. and IX. The courtyard or air-well which was open has now been partially closed, as in Plan IX., and completely covered in, as in Plan VIII. Buildings of this kind resemble long narrow tunnels.

Plan X. represents a four-storied tenement house which runs through from Sago Street to Sago Lane. Originally, it consisted of two separate houses placed back to back in the fashion described already, in rather a narrow block. One of the houses faced Sago Street and was known as 20–3 Sago Street, and the other faced Sago Lane and was known as 18 Sago Lane. Now there is an entrance to the lower floor from Sago Lane, but the second, third and fourth stories can only be entered from Sago Street. The conditions under which the tenants of the lower floor of this house live are set forth in some detail, as they are to be found in a very large number of the cubicle houses in the Chinese quarters. On the lower floor of 20–3 Sago Street is a shop tenanted on one side by a barber, who carries on his trade there; and on the other side by a tailor, who is also busy at his work. Behind the shop is a central and badly-lighted passage, having on either side of it cubicles which, like all similar cubicles, are pitch dark in their interior. On the tailor side of the passage there are six cubicles. A lamp is necessary for their inspection.

The first is occupied by the tailor and a food hawker, the second by a general goods hawker or haberdasher. His cubicle is crowded with stores of all kinds, such as boots, shoes, pipes, whistles, soap, towels, lamps, tooth-powder, &c. The bench on which he sleeps is 22 ins. wide and $5\frac{1}{2}$ ft. long, and there is only 18 ins. between it and an upper shelf containing some of his goods. It is truly a tight fit. The third cubicle is occupied by two food hawkers, one sleeps on a bench below, and the other on a bench above, as in bunks on board ship. In the cubicle is a stove with dishes, which is carried by Chinese hawkers selling food; there are also stores of salt, rice, vermicelli, &c. The fourth cubicle contains three beds; it is occupied by two hawkers, one of whom is suffering from cough and is spitting on the floor. There is no food in the cubicle as they have sold everything and are about to buy a fresh supply.

The fifth cubicle is occupied by one man, who is evidently thriving. It has a table on which are laid out strings of cash. Apparently he has been making out his accounts, but, like the others, he needs a lamp. He sells ducks which he keeps in baskets in the air-well, and he prepares them for food in the kitchen behind the cubicles.

The sixth cubicle contains two beds, one above the other. The occupants are fruit sellers and have some kind of fruit steeping in four barrels, which appear to contain vinegar.

Coming to the barber's side, behind his cubicle is another occupied by two coffee sellers. One is asleep in his bed at the time of the visit. His food utensils are under his bed. Behind the coffee-seller's cubicle is the air-well stacked with baskets, some of which contain ducks and chickens belonging to the several food hawkers occupying the lower floor. Behind the air-well are two other cubicles, one is occupied by a fruit and food hawker. It is his store as well as his sleeping room. There are apples, eggs, preserved pig, mangoes, many of which are over-ripe and rotten, and other kinds of fruit. There are also his buckets, pails and utensils. Behind this is another cubicle, also occupied by a hawker. This time it is a hawker of Chinese medicines and tea. Over his bed are wide shelves containing baskets full of medical herbs. There are also on the small bench brass vessels containing syrups, and metal vessels containing water, and under the bed, as in all the cubicles, there is an immense quantity of rubbish and filth ; a night visit discovered the place to be overrun with cockroaches and other vermin.

Behind the range of cubicles is the cookhouse, which was formerly a back area. It is quite dark, but relatively it is less so than the cubicles, because it obtains a glimmer of light from an opening which remains to let out the smoke of the kitchen. There are several water barrels with water in them, but there is no water tap. The barrels are filled from an adjoining cookhouse common to this floor and that of the house at the back which fronts on Sago Lane. The chopping block in the cookhouse which is used for preparing the meats is covered with slime, and the drain from the kitchen and from the stories above passes under one set of cubicles to discharge itself into the open drain in the street. This kitchen of No. 20–3 Sago Street communicates by a side door with a smaller, but almost equally dark, kitchen belonging to 18 Sago Lane. The latter has a water tap, and it also possesses a latrine, which is a small wooden erection. From this kitchen a door leads into the ground floor of Sago Lane, which has a passage down the centre and cubicles on either side ; but as the room is not very deep, it has only three on one side and two on the other before the front room is reached. The second, third, and fourth stories are similarly subdivided.

17. Some details regarding cubicles.

The following details with regard to the cubicles and their inmates in this house, with reference to number of cubicles, area, rent, number of occupants in each, and occupation of the inmates, are useful, as they serve as a sample of that which obtains more or less in other tenement and shop houses, whether two-storied, three-storied or four-storied. In some tenement houses there are many more married people and larger numbers of single women.

20–3 SAGO STREET AND 18 SAGO LANE.

Owner ... ... Ezra Nathan.
Occupation ... ... Share broker.
Assessed at ... ... $120 per mensem.

20–3 SAGO STREET.

Ground Floor.

Occupier ... ... Siew Ah Hee.
Occupation ... ... Food hawker.
Rent ... ... $20 per mensem.

Shop in Front.

Barber and Tailor.

Number of workmen ... ... 2 males.
Rent ... ... $6 per mensem.

No. 1 Cubicle.

Area ... ... 67½ square feet.
Number of occupants ... ... 2 males.
Occupation ... ... Food hawker and tailor.
Rent ... ... $2 per mensem.

No. 2 Cubicle.

Area ... ... 45½ square feet.
Number of occupants ... ... 1 male.
Occupation ... ... Haberdasher.
Rent ... ... $2.50 per mensem.

No. 3 Cubicle.

Area ... ... 52½ square feet.
Number of occupants ... ... 2 males.
Occupation ... ... Fruit hawker.
Rent ... ... $2.50 per mensem.

No. 4 Cubicle.

Area ... ... 63 square feet.
Number of occupants ... ... 3 males.
Occupation ... ... Food hawkers.
Rent ... ... $3 per mensem.

No. 5 Cubicle.

Area ... ... 56 square feet.
Number of occupants ... ... 1 male.
Occupation ... ... Food hawker.
Rent ... ... $2.60 per mensem.

20–3 SAGO STREET (*continued*).

Ground Floor (*continued*).

No. 6 Cubicle.

Area	63 square feet.
Number of occupants	2 males.
Occupation	Fruit hawker.
Rent	$2 per mensem.

No. 7 Cubicle.

Area	56 square feet.
Number of occupants	1 male.
Occupation	Medicine tea seller.
Rent	$2 per mensem.

No. 8 Cubicle.

Area	84 square feet.
Number of occupants	1 male.
Occupation	Fruit hawker.
Rent	$4 per mensem.

No. 9 Cubicle.

Area	77 square feet.
Number of occupants	2 males.
Occupation	Coffee seller.
Rent	$4 per mensem.

No. 10 Cubicle.

Area	28 square feet.
Number of occupants	1 male.
Occupation	Barber.
Rent	$2 per mensem.

Total area of cubicles	592½ square feet.
Total occupants ground floor ...	19 males.
Total rent paid by occupier ...	$20 per mensem.
Total rent paid by sub-tenants	$32.60 per mensem.
Square feet for each occupant...	31 square feet.

N.B.—Cubicles are numbered from the right when entering the house.

First Floor.

Occupier	Lim Ah Heng (sleeps in passage).
Occupation	No occupation.
Rent	$20 per mensem.

No. 1 Cubicle.

Area	80 square feet.
Number of occupants	1 male.
Occupation	Revenue officer.
Rent	$4.50 per mensem.

20–3 SAGO STREET (*continued*).

First Floor (*continued*).

No. 2 Cubicle.

Area	64 square feet.
Number of occupants	1 female and 1 child.
Occupation	Seamstress.
Rent	$2.30 per mensem.

No. 3 Cubicle.

Area	56 square feet.
Number of occupants	1 male, 1 female and 2 children.
Occupation	Tailor.
Rent	$2 per mensem.

No. 4 Cubicle (vacant).

Area	70 square feet.
Rent, if occupied	$1.80 per mensem.

No. 5 Cubicle.

Area	70 square feet.
Number of occupants	2 males.
Occupation	Painter and decorator.
Rent	$1.50 per mensem.

No. 6 Cubicle.

Area	80 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Rickshaw puller.
Rent	$2.80 per mensem.

No. 7 Cubicle.

Area	75 square feet.
Number of occupants	2 males.
Occupation	Fruit sellers.
Rent	$2.80 per mensem.

No. 8 Cubicle (vacant).

Area	70 square feet.
Rent, if occupied	$2 per mensem.

No. 9 Cubicle (vacant).

Area	132 square feet.
Rent, if occupied	$3.50 per mensem.

Total area of cubicles	697 square feet.
Total occupants	14 (males 7, females 3, children 4).
Total rent paid by occupier ...	$20 per mensem.
Total rent paid by sub-tenant...	$23.20 per mensem.
Square feet per occupant ...	50 square feet.

20–3 SAGO STREET (*continued*).

Second Floor.

Rent collected by Owner's Agent.

No. 1 Cubicle (vacant).

Area	92 square feet.
Rent, if occupied	$4.50 per mensem.

No. 2 Cubicle.

Area	80 square feet.
Number of occupants	1 male and 1 female.
Occupation	Gambler.
Rent	$2.50 per mensem.

No. 3 Cubicle.

Area	80 square feet.
Number of occupants	2 females.
Occupation	Coolies (pepper).
Rent	$2 per mensem.

No. 4 Cubicle.

Area	104 square feet.
Number of occupants	2 males.
Occupation	Fruit sellers.
Rent	$1.50 per mensem.

No. 5 Cubicle.

Area	64 square feet.
Number of occupants	2 males.
Occupation	Carpenters.
Rent	$1.40 per mensem.

No. 6 Cubicle.

Area	96 square feet.
Number of occupants	1 female and 1 child.
Occupation	Prostitute.
Rent	$3.50 per mensem.

No. 7 Cubicle.

Area	88 square feet.
Number of occupants	1 male and 1 child.
Occupation	General dealer.
Rent	$3 per mensem.

No. 8 Cubicle.

Area	80 square feet.
Number of occupants	3 males.
Occupation	Cargo coolies.
Rent	$2.30 per mensem.

20–3 SAGO STREET (*continued*).

SECOND FLOOR (*continued*).

No. 9 Cubicle (vacant).

Area	92 square feet.
Rent, if occupied	$4 per mensem.

Total area of cubicles	776 square feet.
Total occupants	15 (9 males, 4 females, 2 children).
Total rent paid by sub-tenants	$24.70 per mensem.
Square feet per occupant ...	52 square feet.

THIRD FLOOR.

Occupier	Low Chee.
Occupation	Fitter.
Rent	$12 per mensem.

No. 1 Cubicle.

Area	88 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Fitter.
Rent	$4.50 per mensem.

No. 2 Cubicle (vacant).

Area	63 square feet.
Rent, if occupied	$2 per mensem.

No. 3 Cubicle.

Area	70 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Bootmaker.
Rent	$2 per mensem.

No. 4 Cubicle.

Area	70 square feet.
Number of occupants	1 male and 1 female.
Occupation	Cargo coolie.
Rent	$2 per mensem.

No. 5 Cubicle.

Area	96 square feet.
Number of occupants	4 males.
Occupation	Seaman.
Rent	$5 per mensem.

No. 6 Cubicle.

Area	104 square feet.
Number of occupants	1 male and 1 female.
Occupation	Ship's cook.
Rent	$3 per mensem.

20–3 SAGO STREET (*continued*).

Third Floor (*continued*).

No. 7 Cubicle.

Area	100 square feet.
Number of occupants	1 male and 1 female.
Occupation	Carpenter.
Rent	$4.50 per mensem.

Total area of cubicles	591 square feet.
Total occupants	16 (9 males, 5 females, 2 children).
Total rent paid by occupier ...	$12 per mensem.
Total rent paid by sub-tenants	$23 per mensem.
Square feet per occupant ...	37 square feet.

18 SAGO LANE.

Ground Floor.

Occupier	Chan Ah Kow.
Occupation	Doctor (lady).
Rent	$11 per mensem.

Nos. 1 and 2 Cubicles.

Area	90 square feet.
Number of occupants	2 males, 1 female and 2 children.
Occupation	Ship's carpenters.
Rent	$4.50 per mensem.

No. 3 Cubicle.

Area	42 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Ship's carpenter.
Rent	$3 per mensem.

No. 4 Cubicle (vacant).

Area	76 square feet.
Rent, if occupied	$2.20 per mensem.

No. 5 Cubicle.

Area	63 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Doctor (lady).
Rent	$6 per mensem (including shop).

Total area of cubicles	271 square feet.
Total occupants	11 (4 males, 3 females, 4 children).
Total rent paid by occupier ...	$11 per mensem.
Total rent paid by sub-tenants	$15.70 per mensem.
Square feet per occupant ...	Nearly 25 feet.

18 SAGO LANE (*continued*).

First Floor.

Occupier ... ... Lim Ah Heng.
Occupation ... ... None.
Rent ... ... $10 per mensem.

No. 1 Cubicle.

Area ... ... 86¼ square feet.
Number of occupants ... ... 3 males.
Occupation ... ... Engineers.
Rent ... ... $3.50 per mensem.

No. 2 Cubicle.

Area ... ... 82½ square feet.
Number of occupants ... ... 2 females.
Occupation ... ... Seamstress.
Rent ... ... $2 per mensem.

No. 3 Cubicle.

Area ... ... 60 square feet.
Number of occupants ... 1 male.
Occupation ... ... Brass smith.
Rent ... ... $2 per mensem.

No. 4 Cubicle.

Area ... ... 60 square feet.
Number of occupants ... ... 2 males.
Occupation ... ... Painter.
Rent ... ... $1.60 per mensem.

Nos. 5 and 6 Cubicles.

Area ... ... 168¾ square feet.
Number of occupants ... ... 1 male, 1 female and 1 child.
Occupation ... ... Tailor.
Rent ... ... $5.50 per mensem.

Total area of cubicles ... ... 457½ square feet.
Total occupants ... ... 11 (7 males, 3 females, 1 child).
Total rent paid by occupier ... $10 per mensem.
Total rent paid by sub-tenants $14.60 per mensem.
Square feet per occupant ... 41 ft.

Second Floor.

Rent collected by Owner's Agent.

No. 1 Cubicle (vacant).

Area ... ... 88 square feet.
Rent, if occupied ... ... $4 per mensem.

18 SAGO LANE (*continued*).

Second Floor (*continued*).

No. 2 Cubicle (vacant).

Area	76½ square feet.
Number of occupants	3 males.
Occupation	Carpenters.
Rent	$2.30 per mensem.

No. 3 Cubicle.

Area	76½ square feet.
Rent, if occupied	$2.20 per mensem.

No. 4 Cubicle.

Area	76½ square feet.
Number of occupants	2 males.
Occupation	Carpenters.
Rent	$2.20 per mensem.

No. 5 Cubicle.

Area	72 square feet.
Number of occupants	2 males.
Occupation	Carpenters.
Rent	$2 per mensem.

No. 6. Cubicle (vacant).

Area	88 square feet.
Rent, if occupied	$4 per mensem.

Total area of cubicles	477½ square feet.
Total occupants	7 males.
Total rent paid by sub-tenants	$16.70 per mensem.
Square feet per occupant ...	68 feet.

Third Floor.

Occupier	Low Chee.
Occupation	Fitter.
Rent	$8 per mensem.

No. 1 Cubicle.

Area	88 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Carpenter.
Rent	$2.50 per mensem.

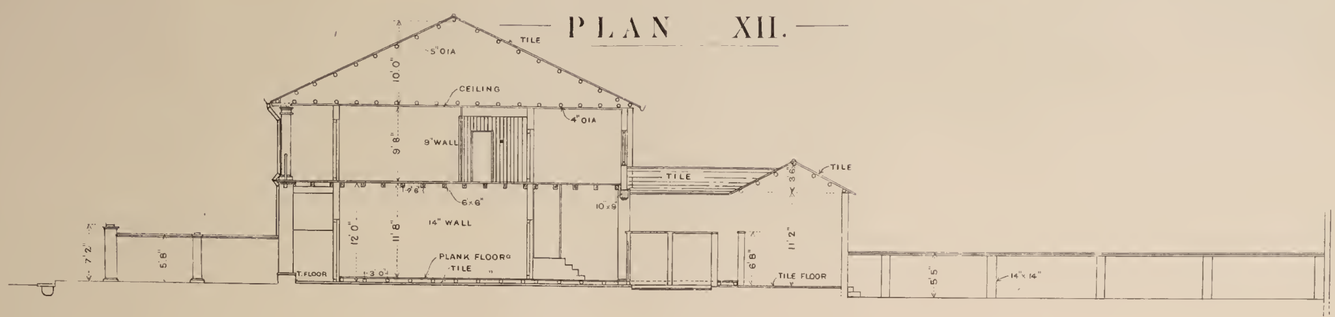
No. 2 Cubicle.

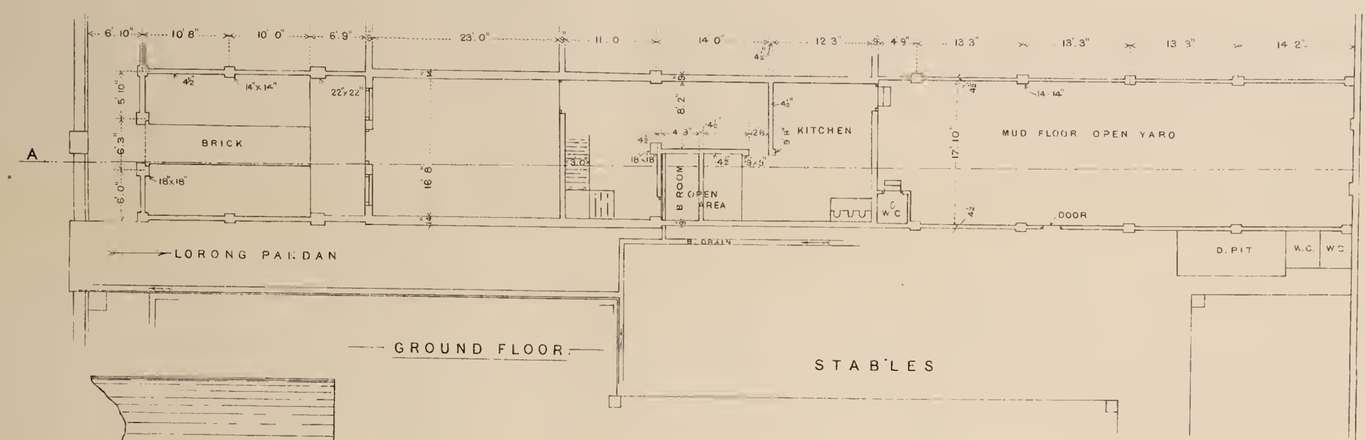
Area	88 square feet.
Number of occupants	1 male, 1 female and 1 child.
Occupation	Fitter.
Rent	$10 per mensem (including front room).

Total area of cubicles	176 square feet.
Total occupants	6 (2 males, 2 females, 2 children).
Total rent paid by occupier ...	$8 per mensem.
Total rent paid by sub-tenants	$12.50 per mensem.

PLANS OF HOUSES IN THE OLD EUROPEAN QUARTERS.

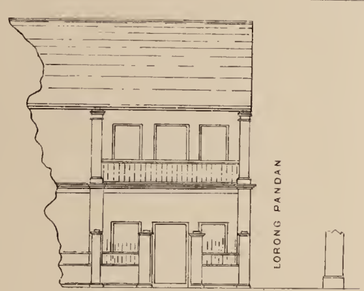
PLAN XII.



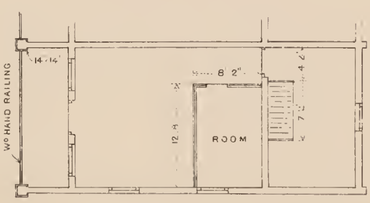


GROUND FLOOR.

STABLES

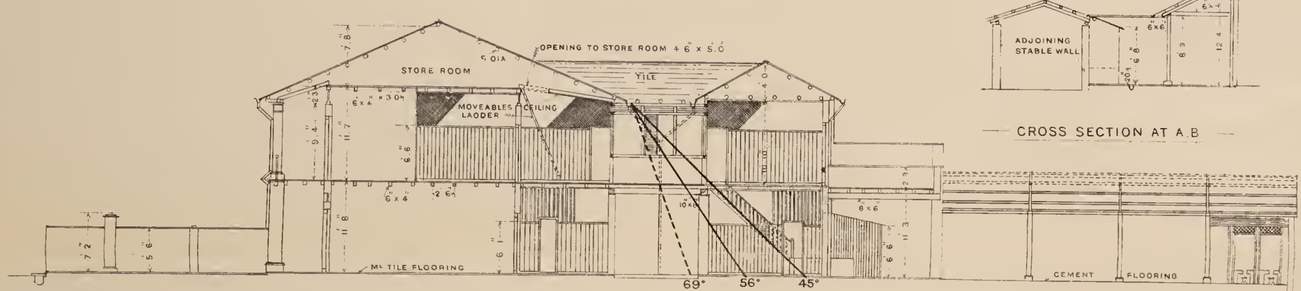


Nº 37 PRINCEP ST



FIRST FLOOR.

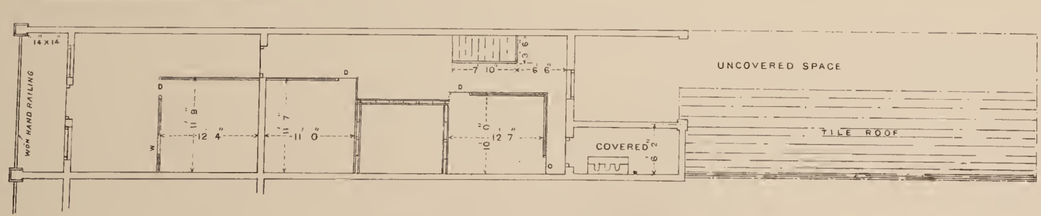
PLAN XIII.



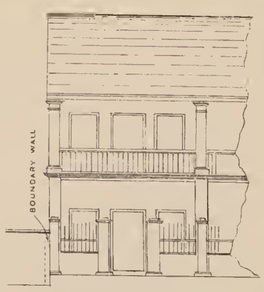
CROSS SECTION AT A.B

Thick dotted line indicates existing angle for open space.
Thick straight lines indicate angles which should be allowed for open space, 56° being the angle recommended, but 45° being better.

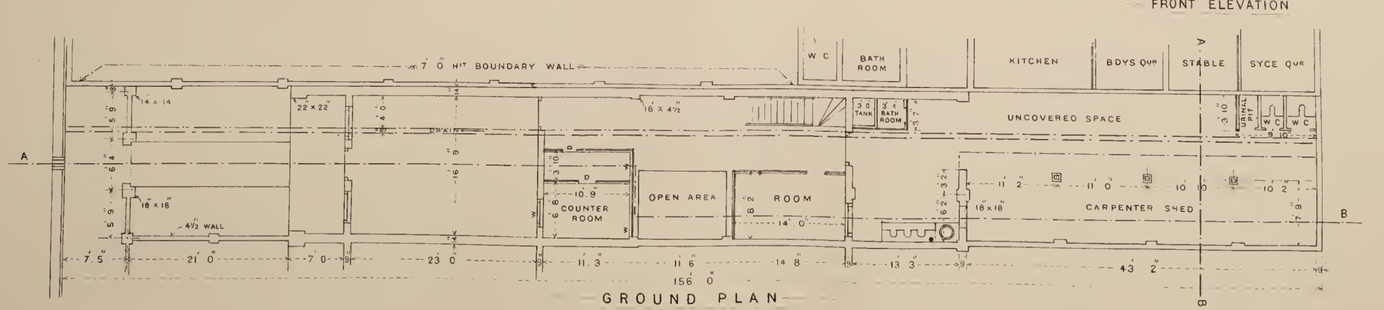
LONGITUDINAL SECTION THROUGH A B



FLOOR PLAN



FRONT ELEVATION



GROUND PLAN

Nº 42 PRINCEP ST

WATERLOW & SONS LIMITED LONDON WALL LONDON

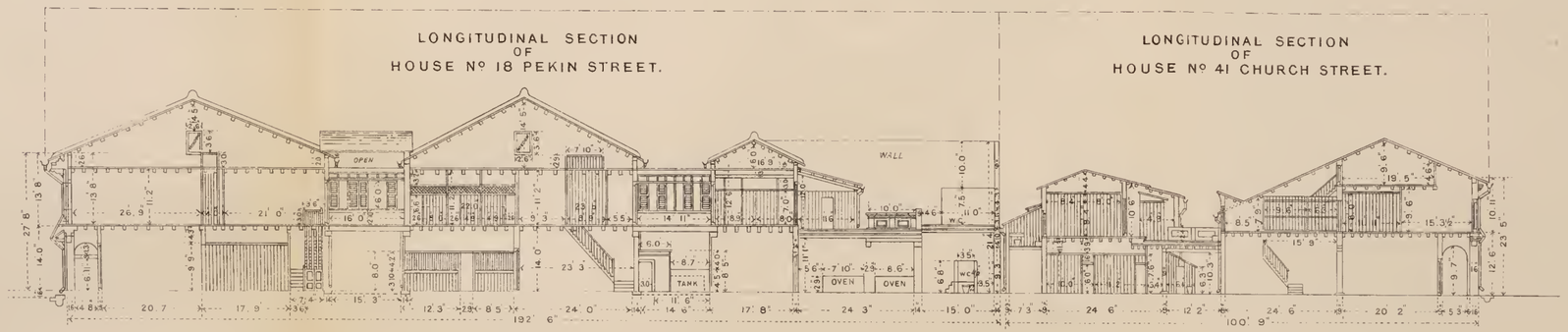
SECTION OF BACK TO BACK CHINESE DWELLING HOUSES.

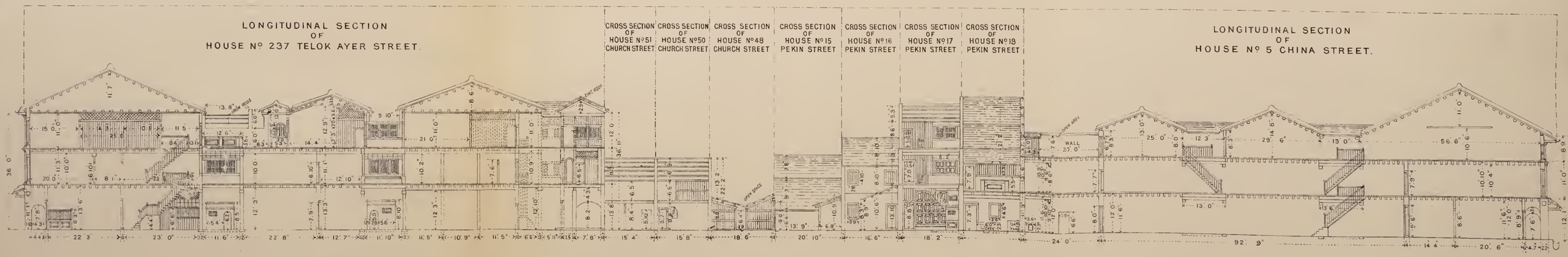
IN

PEKIN STREET, TELOK AYER STREET, CHURCH STREET & CHINA STREET.

SCALE, 24 FEET TO 1 INCH.

PLAN XI.





WATERLOW & SONS LIMITED LONDON WALL LONDON

PHOTO IV.

The interior of a cubicle and its furnishings. It is a windowless room and pitch dark.
Photo taken by magnesium light.

PHOTO III.

Central passage in upper floor of a tenement house, with cubicles on each side.

PHOTO II.

Central passage of lower floor in tenement house, with cubicles on each side.

Photo taken by magnesium light.

PHOTO I.

Central passage on lower floor of tenement house. Figures indicate position of entrance to dark cubicles.

Photo. I. shows the dark central passage on the lower floor of a tenement house. On each side of the passage are dark cubicles, the entrance to each of which is indicated by the position of the figures in the passage.

Photo. II. shows a similar arrangement in another house. This photo. was taken with the magnesium light.

Photo. III. shows the central passage and cubicles in the upper floor of a third house.

Photo. IV. shows the interior of a cubicle and its furnishings. It is a windowless room and pitch dark. The photo. was taken by means of the magnesium light.

Plan XI. represents a section of back-to-back Chinese dwelling houses in an irregular block, and shows the extent to which the interior of the block is filled up.

Plans XII. and XIII. represent houses in the old European quarters.

18. The danger to new and open districts.

Plan XII., without the 20 ft. in front, is similar in arrangement to that which obtained in the early days in the Chinese quarter, and of which there are traces in some parts to-day. It is a two-storied house, 40 ft. in depth and 17 ft. in width, with a tile-roofed verandah 8 ft. in width running out behind and leading to a one-storied kitchen. Behind the kitchen is an open yard or garden abutting on the wall of the property in the rear which has its frontage in another street. The uncovered area of the building site, not counting the front garden, is more than half the covered area.

Plan XIII. illustrates the change for the worse which such a healthy house may undergo by the process of accretion, which brings another building of two stories in height too close to the first building and only separates it by a central court which is verandahed on one side. It also illustrates the gradual covering over of open space, and if not prevented by efficient building laws there is no doubt a third building will be erected where the carpenter's shed is now situated, and this building plot will then be as effectually filled up as any in the Chinese quarter. This is the danger which can be and should be averted in all those blocks in the town which have not been already filled up.

19. It is clear that the design and construction of the kind of houses referred to, apart from their sub-divisions into cubicles, and quite apart from their relation to other houses, are so defective as to obstruct a free admission of light and a proper circulation of air, and that this defect is aggravated by the sub-division of the interior into cubicles without windows to admit direct sunlight and fresh air.

20 Insanitary areas. If we turn now to the situation of the houses in the block and their relation to one another, it will be found that they are so arranged as to intensify the obstructions to the admission of light and a free circulation

of air which the design of the house itself causes. As one area is almost the same as another, any area which has been filled up with buildings may be taken to illustrate the insanitary conditions that have arisen. Plan XIV., for example, exhibits an area bounded by South Bridge Road on the East, Market Street and Cecil Street on the West, South Canal Road and Kling Street on the North and Cross Street on the South. The streets it will be seen are wide and regular, but the blocks present an amazing crowding together of the houses. In the narrower blocks most of the houses are back to back, while at the ends of the block the houses facing the streets have their backs abutting against the side walls of the nearest houses, and as these side walls are as high as the houses, there is no open space at the rear. In the wider and more irregular blocks the arrangement resembles a piece of mosaic work, nearly every open space having been filled in by a building.

In viewing one of the blocks from the roof of a house, forming a part of street, there appeared to be at least one open space unbuilt on, which was a sort of oasis in a labyrinth of bricks and mortar, but on inspection it was discovered to be a narrow court, having on each side a series of one-storied cabins, which were approached through a cake shop and bakehouse. Photo. V., kindly taken by Dr. Brooke, shows the court and the huts in it. The drain from the huts passes down the courtyard, then through the premises of the bakehouse and cake shop, to the surface drain in the street.

Plans XV. and XVI. are ground plans of two of the narrower blocks, taken separately, with more detailed information concerning the crowding together of houses and of the inhabitants. The utterly inadequate open space allotted for lighting and ventilation of the houses and the absence of back lanes in the blocks to facilitate drainage and scavenging are very clearly demonstrated on these plans.

The following particulars relate to Plan XV., which is the ground plan of the block between Upper Macao Street and Upper Hokien Street :—

Length, 690 ft.
Breadth, 126 ft.
Area built over, 76,940 sq. ft.
Uncovered open space, 5,081 sq. ft.
No. of houses, 87.
No. of inhabitants per acre, 677.

Similar particulars for Plan XVI., the ground plan of the block between Carpenter Street and Hongkong Street, give :—

Length, 542 ft.
Breadth, 212 ft.
Area built over, 114,904 sq. ft.
Uncovered open space, 8,340 sq. ft.
No. of houses, 74.
No. of inhabitants per acre, 435.

— PLAN XIV —

PLAN OF
PART OF SINGAPORE TOWN,
SHOWING SHOP HOUSE BLOCKS.

— SCALE 4 CHAINS TO AN INCH. —

LINKS 100 50 0 1 2 3 4 5 6 7 8 9 10 CHAINS.

WATERLOW & SONS LIMITED LONDON WALL LONDON

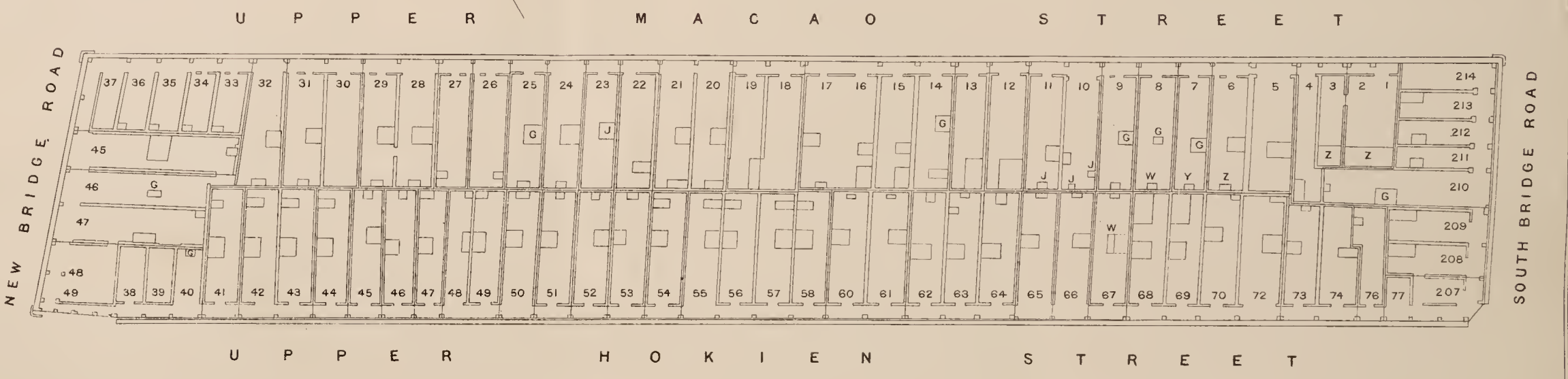
PHOTO V.

Narrow courtyard occupying open space in the interior of a block of houses.

PLAN
SHOWING BACK TO BACK HOUSES
& AIR WELLS.

SCALE 66 FEET TO AN INCH.

— PLAN XV —



— PLAN XVI —

NOTE:—
G denotes glazed roofing.
J „ jack „
W „ wooden grating.
Z „ zinc covering.
Space opened to sky is not lettered.

WATERLOW & SONS LIMITED LONDON WALL, LONDON

PHOTO VI.

Malay hut on one of the mud flats of the Singapore River

PHOTO VII.

Hut in which dark dwelling rooms have been constructed underneath the original floor.

PLAN SHOWING IRREGULAR BLOCK
WITH
BACK TO BACK HOUSES.

SCALE 66 FEET TO 1 INCH.

PLAN XVII

NOTE:- COLOURED RED SHEWING VENTILATING ROOF
MARKED G " GLASS ROOF.
OPEN TO SKY SHEWN THUS □

WATERLOW & SONS, LIMITED, LONDON WALL, LONDON

In the first block the amount of open space to the covered-over area is only 6 per cent., and in the second block only 7 per cent., instead of 33 per cent., which should be the minimum.

Plan XVII. shows the ground plan of an irregular block of houses.

21
Other insanitary areas.

Reference requires also to be made to another class of house, which, owing to deterioration in design, crowding together, and other causes, are producing insanitary areas of another kind to that which is caused by the Chinese mode of building. I refer to the housing of the Malays. As a general rule the Malays live in better lighted and better ventilated dwellings than the Chinese, but they have selected sites that are low-lying and liable to floods, either from high tides or from a heavy rainfall. Their best sites are on inlets of the sea, when their houses of wood or attap, erected on piles, stand over the sea, and everything which has been thrown from the house, together with the sulliage and sewage, is swept away by the tide. The primitive domestic arrangements for the removal of effete matters serve their purpose under these circumstances and the house is a healthy one. But when, as in Singapore, the site selected is low-lying and undrained, and the huts are built in an irregular fashion, and when, by the stress of circumstances or from imitation, damp and dark dwelling rooms are constructed underneath the hut and between the piles, the result is a very unhealthy area of houses.

Photo. VI. shows Malay huts erected on one of the mud flats of the Singapore River, and which is partially covered by the tide.

Photo. VII. shows a hut in Kampong Boyan in which dwelling rooms have been constructed under the original floor of hut and converted into a lower floor.

The Kampong Boyan and the Kampong, in Weld Road and Dixon Road, may be taken as examples of unhealthy areas of a different kind to those already dealt with.

Kampong Boyan, in Syed Ali Road, is a collection of wooden huts inhabited by Boyanese. The huts are erected on piles and mostly detached but ill-arranged, the majority being too close to one another. The site is low, and when the tide is exceptionally high the river water floods the ground for several inches high underneath the piles. In between the piles and underneath the huts there have been constructed rooms which, by their situation, are dark and damp. This arrangement of converting the space between the piles into dwelling rooms is evidently not in the original design, nor is it in conformity with the customary conditions under which the Malay lives. The huts themselves, minus this excrescence, if planned out on regular lines with sufficiency of space between them to the extent of 6 or 8 ft., would be well lighted and ventilated, for their design is in favour of these. The huts are raised well above the ground on piles approached by a stair leading to a verandah, which gives entrance to a central hall with rooms on either side having windows into the space intervening between the huts. Behind the central

hall is the kitchen, and behind this, but separated from the kitchen by a certain spaee, is the bathroom and latrine.

In the case of Kampong Boyan the closeness of the huts, and their bad arrangement, the dark and damp rooms under the huts, the absenee of drainage and proper eonvenienees, and the soakage of sulliage water from the kitchen and bathroom into the ground beneath, produce a most unsanitary area.

The Malay Kampong, in Weld Road and Dixon Road, is a collection of huts similar to Kampong Boyan but with more open spaee. The site, however, is low lying and is subjeet to floods after heavy rain and during high tides. The rooms of huts whieh have been constructed between the piles and which are dark and badly ventilated are, aecordingly, exposed to these periodical floodings. Behind the huts latrines, wells and stagnant drains eontribute, by their eondition, to the unhealthy state of the premises.

These and others like them are unhealthy areas, inhabited by the Malays, and, as sueh, should be dealt with. But as the people are poor, although owners of the land and the huts, it might well be a question for consideration, whether the Municipality should not itself raise the land for them, leaving the owners to rebuild their huts on a definite plan in regular lines and on sanitary principles. It might be possible even to go further and, under proper seeurity, grant a loan to these people to assist them in rebuilding their houses, provided that on failure to eomply with the conditions of the loan the Munieipality possesses power to expropriate.

22. Summary of the conditions which make for unhealthiness in the housing at Singapore.

The conditions which make for unhealthiness in regard to housing in Singapore may be summed up as follows :—

I. The excessive eovering of the *site for a dwelling house,* or *house site* with buildings.

II. The adoption of a style of building which, except in the ease of detaehed houses with lateral windows and ample eourtyard and baekyard spaee, shuts out from the interior of the house an adequate and neeessary supply of sunlight and fresh air.

III. The sub-division of the floors and rooms into eubieles without provision for eaeh eubicle of windows opening direetly into the external air.

IV. The eonversion of private houses and other buildings into tenement houses without sanetion and approval of the plans by the Munieipality.

V. The absenee of baek lanes and open yards to allow of drainage, seavenging and a free circulation of air.

VI. The erowding together to the greatest extent possible of houses on *building areas or blocks.*

VII. The irregularity with which Malays' huts and houses are built, and the construction of dark and unhealthy lower rooms, which are not raised from the ground and not protected by proper plinths from being periodically flooded.

VIII. Overcrowding of the houses with inhabitants under adverse conditions of light, air and drainage.

It is evident that Singapore, though covering a very extensive area, is suffering, even in this early stage of its development, from two forms of overcrowding. The first is overcrowding of areas with houses, and the second is overcrowding of houses with inhabitants. These two factors are well-known causes of high death-rates, and the remedy lies in the removal of these causes in the old localities and in their prevention in the new and in those parts of the old not yet overbuilt on.

23. Methods by which these conditions can be removed and prevented from repeating themselves.

Their removal can be effected (1) by giving back lanes to the existing houses, as by the scheme proposed by the Committee consisting of Dr. McDowell, Dr. Middleton and Mr. Pierce; (2) by opening up the dark and airless portions of houses which are now unhealthy owing to their defective construction; (3) by removal of all cubicles from the ground floors of houses; (4) by the removal of all cubicles on other floors except those that open directly into the external air or have an open skylight in the roof; (5) by enforcing the section against overcrowding; (6) by holding the owner of the houses responsible for these conditions.

Their prevention can be secured :—

(1) By stopping at once the erection of houses without back lanes.

(2) By insisting on a definite minimum proportion of uncovered area to built over area on every house site.

(3) By fixing a definite relationship between the open space in courtyards and between buildings, and the height of the buildings facing them. The erection of two-storied and three-storied buildings behind air-wells which are miniature courtyards should be prohibited unless the size of the air-well is proportionate to the height of the building.

(4) By limiting the depth of dwelling houses without lateral windows.

(5) By favouring the erection of tenement cubicle houses.

(6) By the Municipality preparing an extension plan of the town, permitting no houses to be built within the town except on the lines of those extensions, restricting the number of houses per acre, and apportioning of open spaces. In this manner the larger lines of communication, the ordinary streets, scavenging lanes, open spaces and pleasure grounds are provided in whatever direction the town may extend.

This mapping out of the town would put an end to the haphazard and unhealthy development which is now taking place.

In this connection the Municipality should have power to specify the class of buildings in specified areas. This would prevent the blocking of air spaces behind houses as occurs at the present time. A number of houses are erected with back yards giving an open space for the free circulation of air in and around the houses; then one or more Chinese-styled houses are erected in the same block, but they are deeper and higher, and are obstructive buildings in that block for they obstruct the free circulation of air in and around their neighbours as well as their own.

The general principles to be followed in a plan of this kind are :—

(1) That the blocks in which shop-houses are likely to be erected should not be of too great a depth.

(2) That the houses constituting each section of a block shall have at their rear a lane not less than 15 ft. and not more than 20 ft. wide for the purposes of scavenging and drainage.

(3) That the houses built fronting the main street shall have at their rear an open space between them and the boundary wall of the lane.

(4) That in the centre of the town not more than two-thirds of the house site within the boundary wall shall be covered and not less than one-third remain uncovered, and in the outer ring of the town that not more than one-half of the house site should be covered. These should be laid down as minimum limits, but every effort should be made to induce house builders and owners to leave more space.

(5) Warehouses and godowns should be placed in a different category from dwelling houses. They should be in blocks by themselves and not in blocks in which there are dwelling houses, otherwise if they are placed in blocks with dwelling houses they must conform to the regulations laid down for dwelling houses.

(6) No buildings of any description on any Government property, inside or outside Municipal limits, and no buildings outside Municipal limits, should be erected without the submission of plans to and their approval by the Principal Civil Medical Officer.

24. Additional powers required to remove unhealthy condition of buildings.

In order that the unhealthy conditions mentioned shall be effectively dealt with certain additional powers are required. The existing building laws and bye-laws are inadequate to deal with them, even when supplemented by the bye-laws which have been recently passed and which are an advance on the old. The powers required may be classed under two headings :—

I. Those which deal with future buildings and with future alterations of old buildings.

II. Those which deal with existing conditions.

The first class should be obtained and put into force as soon as possible in order to arrest the deterioration which is now going on, and to prevent the further creation of insanitary areas.

25. Powers relating to site area and buildings.

To prevent excessive building on a house site, *i.e.*, on the area within the boundary wall of the premises on which the house is to be built, three important powers are necessary :—

(*a*) The first is to limit and control the amount and extent of building to be erected on a site and to fix the maximum proportion of the site for a dwelling house which may be built on.

(*b*) The second is to regulate the amount of open space in any building so as to be proportional to the height, that is, the amount of open space in the central court and back yard shall be so much if the house is one storey, so much more if it is two-storied and so much more if it is three-storied.

(*c*) The third is to limit the depth of a building, unless it has lateral windows opening directly into the external air with adequate space for circulation of air and admission of light.

26. Maximum proportion of site to be built upon.

To limit and control the amount and extent of building to be erected on a site the following law, which is in operation in Calcutta and Hongkong, and has been adopted by the Improvement Trust in Bombay, will attain the object in view.

"*The total area covered by all the building, including verandahs, on any site used for a dwelling-house shall not exceed two-thirds of the total area of the site.*"

This limitation would do very well for the more populous parts of Singapore near the sea, but in view of the many calm days in Singapore it would be advisable for the limit to be raised for houses in the suburbs, and that the total area covered on any site should not exceed one-half of the total area of the site. A law of this kind would not affect even the smaller detached houses to be seen in the central part of the town which, as the subjoined statement shows, have a very large area unbuilt on compared with area built on.

RETURN SHOWING SIZE OF PLOT AND AREA BUILT OVER OF TEN DETACHED HOUSES.

No. and Street.	Size of Plot, square feet.	Area built over, square feet.	
2 Orchard Road	7,500	2,606	
4 Orchard Road	9,000	3,803	
113 Bencoolen Street	7,500	1,737	
95 Waterloo Street	17,600	4,408	
164 Middle Road	7,500	3,507	
73 Middle Road	8,007	3,008	
206 Queen Street	8,000	2,030	
A Scott's Road	15,640	4,142	Suburbs.
49 Killiney Road	12,000	3,222	
48 Killiney Road	12,000	3,830	

27. Open space proportional to height of buildings.

The preceding clause secures that at least a certain proportion of the site area shall be unbuilt on, but, in order that light and fresh air may reach every part of the building, clauses are necessary to secure open space proportional to the height of the building and to limit the depth of a building without lateral windows.

Thus if a central court is provided the clause regulating its size should be as follows :—

> " No portion of any face of a dwelling house abutting on a courtyard shall intersect any of a series of imaginary lines drawn from the opposite face of the house at the level of the plinth, at an angle of 56 degrees with the horizontal. In other words, that the height of any face of a dwelling shall not exceed one-and-a-half times the width of the courtyard measured from such face to the opposite face.
>
> " The minimum width of every such courtyard shall be 10 ft."

These regulations secure that the courtyard shall not be encroached on, and that if new stories are added they must be so set back that the angle remains the same, thus allowing plenty of light and fresh air into the courtyard, however high the house may be.

28. Open space at rear of buildings.

The bye-laws recently passed, regulating the space at the rear of buildings, might remain unaltered, provided that in no instance more than two-thirds of the total area of the site is built on, and the building is not higher than one-and-a-half times the open space. There might also be added a clause to the following effect :—

> " The open space in the rear shall not be enclosed, except by boundary walls not exceeding 10 ft."

This would secure privacy for the lower floor and at the same time not be to any material extent obstructive to the circulation of air.

29. Limitation of depth of buildings which are not lighted laterally.

For the purpose of limiting the depth of a building, without lateral windows, a clause should be inserted providing that :—

> " No domestic building shall hereafter be erected of a greater depth than 45 ft., unless every storey of such building is provided with a lateral window or windows opening into the external air and having a window area equal to not less than one-tenth of the floor area of such storey, in addition to windows of a similar size in front and at the rear of every storey."

There is at present a section which was evidently intended to attain this object of preventing deep buildings. It limits the depth of rooms to 40 ft., unless sufficiently lighted laterally. This, however, is insufficient, for it does not prevent room after room of 39–40 ft. being built, one behind the other, with the narrowest of space between them. If, instead, the regulation is made to apply to buildings, unless sufficiently lighted laterally, then it follows that no building can be erected behind another without sufficient space between them, for it at once comes under the

preceding regulation of an angle of 56 degrees. Similarly, this is the case when a building is to be erected in front of another.

30. Cubicles.

As regards sub-division of floors and rooms into cubicles without provision for each cubicle of windows opening directly into the external air, much of this could be reduced if no building were allowed to be converted into a tenement house, without the submission of plans and their approval by the Municipality. The existing design of building will often admit, on the second storey, of 4 cubicles, each with a window into the external air, viz., two facing the street and two facing the central court. It is only a matter then of intelligent arrangement.

In the case also of a third storey, similar arrangements can be made, with, perhaps, additional cubicles lighted and ventilated from the roof.

No cubicles should, under any circumstances, be permitted on the ground floor.

A clause such as the following would be of service and prevent the construction of windowless rooms :—

> "No cubicle or room shall be constructed or maintained in any storey of a domestic building unless such cubicle or room is provided with a window or windows, or a skylight having a window area not less than one-tenth of such cubicle or room, and opening either directly or across a verandah or balcony into the external air."

Another clause bearing on cubicles should be—

> "No cubicle shall have a less floor area than 80 sq. ft. and a less width or length than 7 ft."

31. Cubicle houses.

Cubicle Houses.—It is impossible to do without cubicles or single room dwellings. The occupants of these are too poor to pay for more than one or two rooms, but however poor they are, they must have privacy, even if it only amounts to a small cabin for sleeping in. This applies not only to married people but to those who are single. The latter require to keep their money and belongings in some place where they shall not be touched by others, and although a number of rickisha coolies and others live a common life in one large room, it is doubtful if many would live in this way if there were other accommodation. The demand for cubicles is so great that no sooner are cubicles pulled down by the Health Department than they are re-erected. In some districts it takes an inspector three months to see the houses in his district, and during the intervals the cubicles are re-erected and the tenant has changed. It is a sisyphus task to attempt to do away with cubicles. It is well to recognise the fact that cubicles are a necessity considering the nature of the population of Singapore, and this being so it is important to devise means by which healthy cubicles shall be provided in place of the dark, unhealthy and windowless rooms that have been described.

To supply the demand I would recommend the building of cubicle houses, *i.e.*, houses in which the upper two stories are sub-divided into a

number of cubicles, each cubicle being provided with a window for light and ventilation, and where the lower storey is used as a shop and warehouse, or shop and living rooms.

Plan XVII. shows the design of a cubicle house which meets with the requirements that every room has a window opening directly into the external air, and that the open space belonging to the house site shall be at least half the covered area. This plan was drawn out by the Public Works Department as an illustration of possible cubicle houses, but there is no need of adopting this particular plan in preference to others which may similarly attain the object in view and which are in accordance with the provisions laid down by the suggested building laws. Once a satisfactory design is obtained its adoption as a standard plan would be an advantage, for by so doing there would be less liability of mistakes being made as the builders and owners of houses would know exactly what was required.

Plan XIX. represents the kind of model shop houses suitable for native traders as distinguished from tenement and cubicle houses.

32. Private and tenement houses.

The conversion of private houses and other buildings into tenement houses, without sanction and approval of the plans by the Municipality, can be prevented by a vigorous enforcement of the existing bye-laws, wherein there are ample powers for this purpose. The responsibility should rest with the owners or agents who collect the rent. Section 152A, as recently included, should run: "No owner or agent shall erect, cause, permit or suffer to be erected."

33. Scavenging lanes.

A clause similar to the following would be required for back lanes:—

> "In the case of all premises forming part of a block there shall be provided, in addition to the open space required at the rear of a domestic building, a scavenging lane of not less than 15 ft., half of which may be provided by adjacent owners."

There would be no necessity for scavenging lanes in districts in which there were only large residential houses isolated and detached in large compounds.

Section 127 of the Municipal Ordinance, 1896, might have scavenging lanes added to it or there should be a section similar to the following:—

> "No new street on land shall be constructed for the purpose of erection of new buildings fronting thereon until a block plan of the whole of the property concerned, showing such proposed street, with its connections with neighbouring streets, together with the proposed levels and scavenging lanes, as well as the proposed method of drainage, shall have been submitted to and approved by the Municipality."

Although the back lane is provided by the owners of the houses on opposite sides, each owner giving $7\frac{1}{2}$ ft., it is necessary, in order to

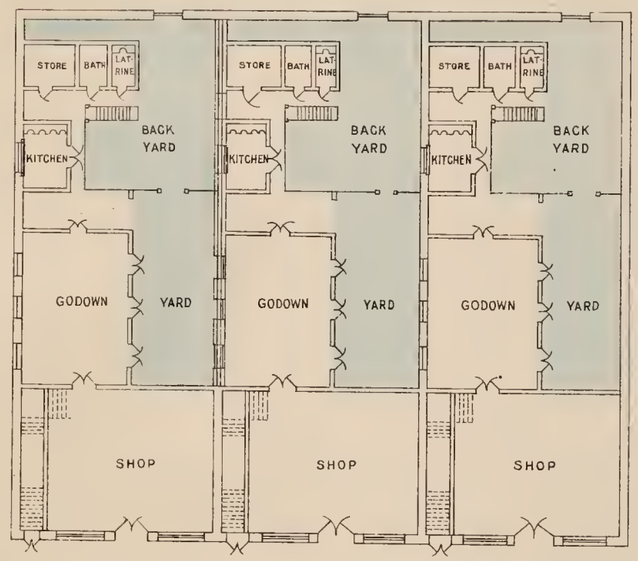
PLAN XVIII

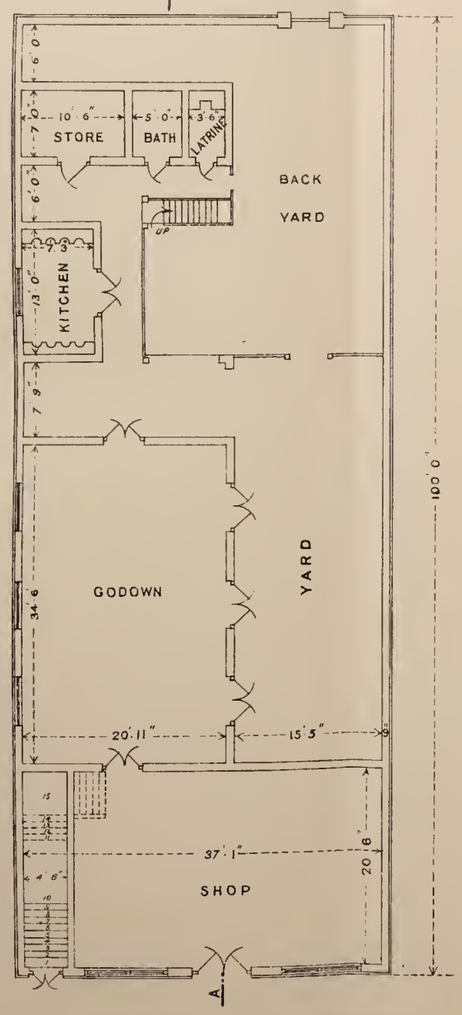
PROPOSED MODEL DWELLINGS FOR COOLIES

SCALE 16 FEET TO 1 INCH

SUPERFICIAL AREA OCCUPIED BY BUILDING 2268 SQ. FT.
SUPERFICIAL AREA OF OPEN SPACE 1446 SQ FT.

LONGITUDINAL SECTION A B.





GROUND FLOOR PLAN.

FIRST FLOOR PLAN.

SECOND FLOOR PLAN.

WATERLOW & SONS LIMITED LONDON WALL LONDON

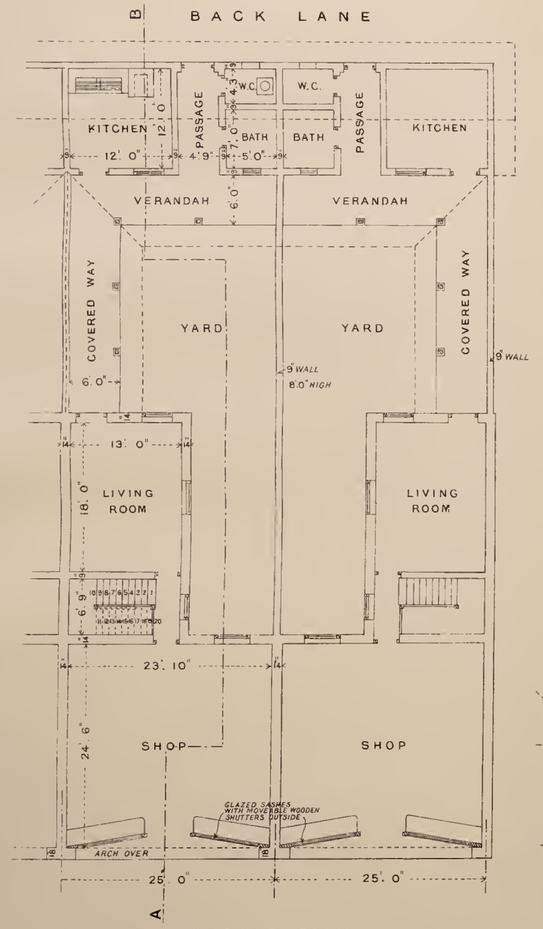
PROPOSED MODEL SHOP HOUSES
FOR
NATIVE TRADERS, SINGAPORE.

SCALE, 16 FEET TO 1 INCH.

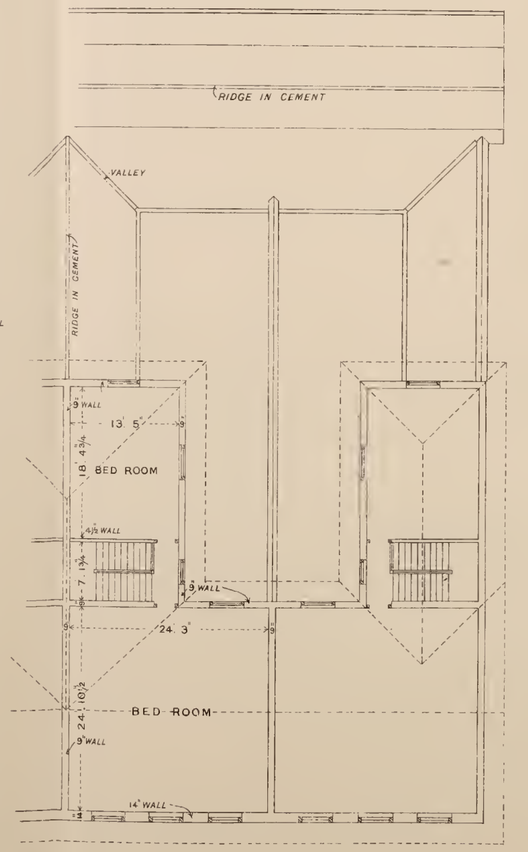
10 5 0 10 20 30 40 50 60

PLAN XIX

SUPERFICIAL AREA OCCUPIED BY BUILDINGS 1830 SQ. FT.
SUPERFICIAL AREA OF OPEN SPACE 681 SQ. FT.

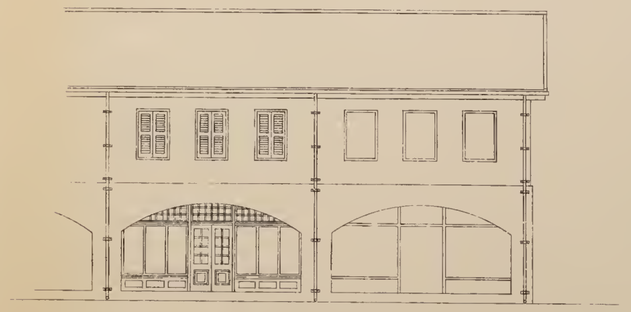


GROUND PLAN.



FIRST FLOOR.

SECTION A.B.



FRONT ELEVATION.

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prevent irregularity and the formation of winding lanes, for the Municipality to lay down the alignment of the lane as is done in regard to streets. The back lanes should be straight. Probably the best width would be 15 ft., to admit of a cart passing through them without injury to the surface drains at the sides, or to the baskets or tubs containing refuse that may have been put out at the back door for the coolie to empty into the cart. It is not desirable that they should be wider than necessary. When made wider than 20 ft. they are apt to be, as they often are, converted into public thoroughfares with frontages on them, thus defeating the object for which they were constructed. It is preferable that any extra open space should be within the boundary wall of opposite houses.

Back lanes are useful for the following purposes :—

1. They facilitate (*a*) drainage, (*b*) scavenging.

2. Add to the air space between the rear of buildings and thus reduce overcrowding on area.

3. Prevent encroachments and extensions backwards, which have been so detrimental to ventilation and a free circulation of air. Any extensions necessitate the acquiring of the adjoining house and not the house in the rear.

4. Form an alignment at the back in the same manner as the street forms an alignment in the front. The alignment is essential to prevent the lanes from being irregular and winding.

5. Define the limits of the boundary of each plot at the back and secure that the amount of site to be covered and left open by the building regulations shall be easily determined and insisted on.

Scavenging lanes are of service to the householder in that they—

(*a*) Permit the refuse to be deposited in baskets in the lane instead of on the public street opposite the front door.

(*b*) Permit the latrine contents to be removed by the coolie without his carrying them through the house and out at the front door.

(*c*) Permit the sulliage water from the kitchen and bathroom to be discharged at once outside the house instead of flowing through the house.

(*d*) Provide drainage lanes for the introduction of the Shone system of drainage.

(*e*) Secure a small air space between the back boundary walls of opposite houses.

34. Further powers required to deal with existing insanitary areas.

The enforcement of the preceding clauses would prevent the formation of unhealthy areas due to crowding together of houses in future building areas and blocks as well as in existing areas which have been

little built on. Further powers are, however, required to deal with existing unhealthy areas, although much improvement can be made, and has been effected, by the employment of Sections 172, 205, 206, 207, 208, 209 and 210, which are powerful sections for dealing with individual houses. It is impossible to secure well lighted and ventilated houses, or a suitable drainage scheme for Singapore with the back-to-back houses and closely packed blocks of houses now existing. The back-to-back houses require at least a lane to be cut through the rears of the houses in each block, in order to open up the congested area and admit light and air to the backs of the houses as well as to provide a lane for scavenging and for drainage. Plans XX., XXI. and XXII., drawn by the Engineer in consultation with me, illustrate the general outline on which improvements should be carried out in blocks of back-to-back houses. The details for each block are a matter for local consideration and will be adapted to the special circumstances of the case. The construction of back lanes in the congested parts of the town involves the removal of portions of masonry buildings of two and three stories in height, but in those parts less congested it often involves the demolition only of a light structure of one storey.

The irregular blocks require more than this, viz., the demolition of insanitary houses in the enclosed area and the construction of scavenging lanes in the rear of the houses fronting the streets, each scavenging lane being continued to join the public street. Plan XXIII. illustrates the manner in which the irregular block, enclosed by Pekin Street, Teloh Ayer Street, Church Street and China Street, may be opened up.

35. Special Ordinance required.

To effect improvements of this kind an ordinance such as is now proposed by the Government of the Straits Settlements, on the lines of the housing of the working classes in England, but adapted to the local conditions and administration of Singapore, is necessary.

36. Suggestions.

A Sanitary Board for the Colony to consider and advise on matters relating to sanitation referred to it by the Governor would be of very valuable assistance to the Government, not only in connection with the proposed Ordinance and the Improvement Scheme of Singapore, but also for the purpose of securing uniformity in sanitary reforms throughout the colony.

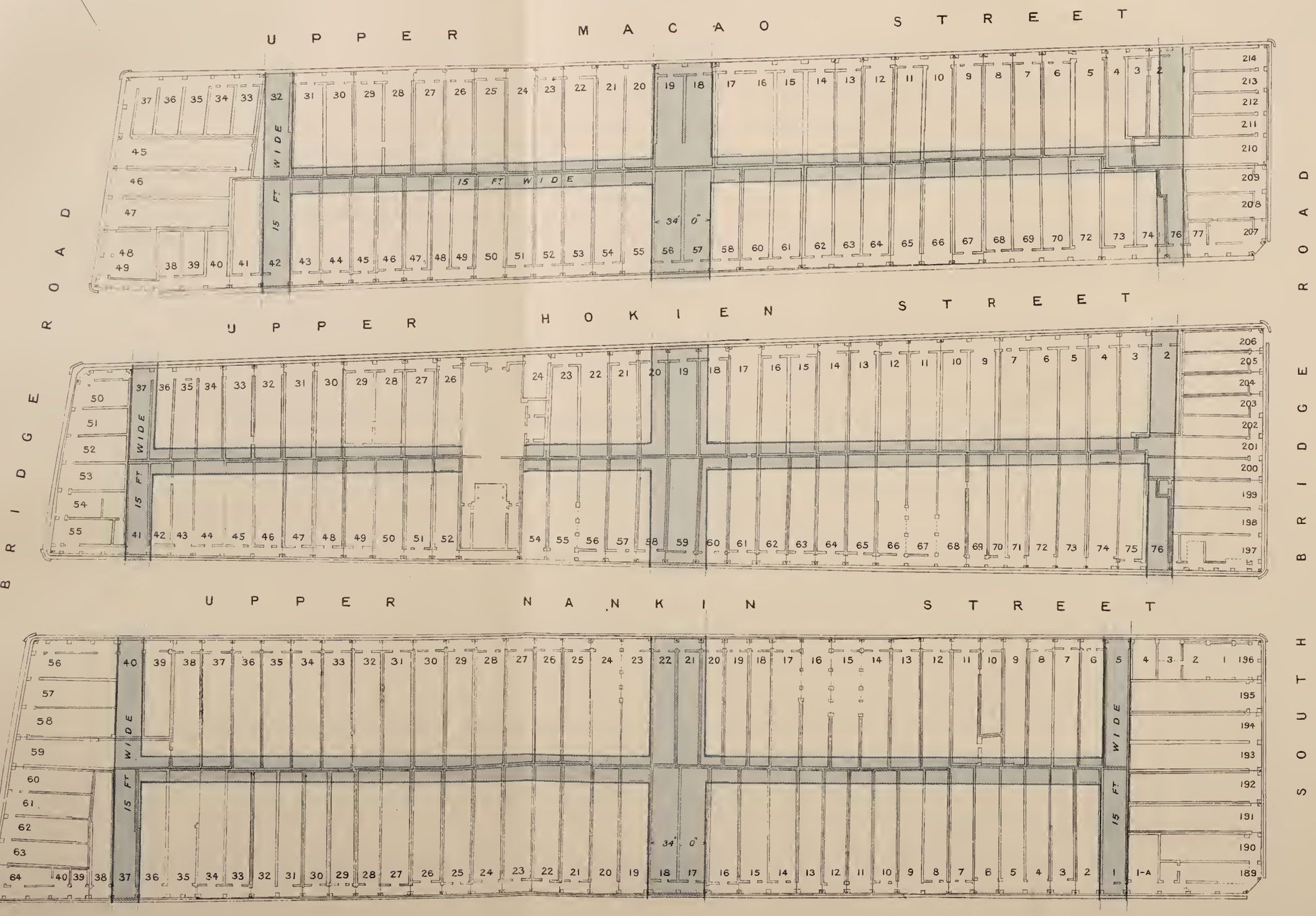
The Sanitary Board might consist of :—

The Principal Civil Medical Officer as Chairman.
The Colonial Engineer.
The Attorney General.
The Collector of Land Revenues.
An unofficial representative of the Legislative Council.
One representative member of the Municipality of Singapore.
One representative member of the Municipality of Penang.
The Health Officer of Singapore.
The Municipal Engineer of Singapore.

PLAN OF BACK TO BACK HOUSES SHOWING PROPOSED IMPROVEMENTS.

— SCALE 66 FEET TO 1 INCH. —

— PLAN XX —



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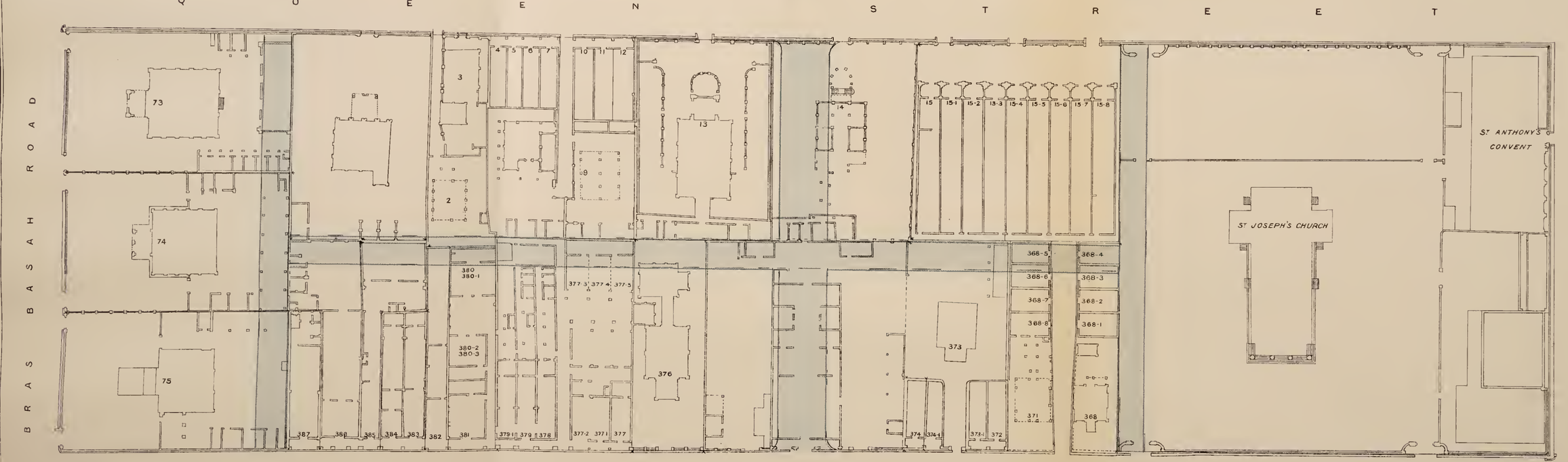
PLAN OF PROPOSED IMPROVEMENTS.

SCALE 66 FEET TO 1 INCH.

PLAN XXI



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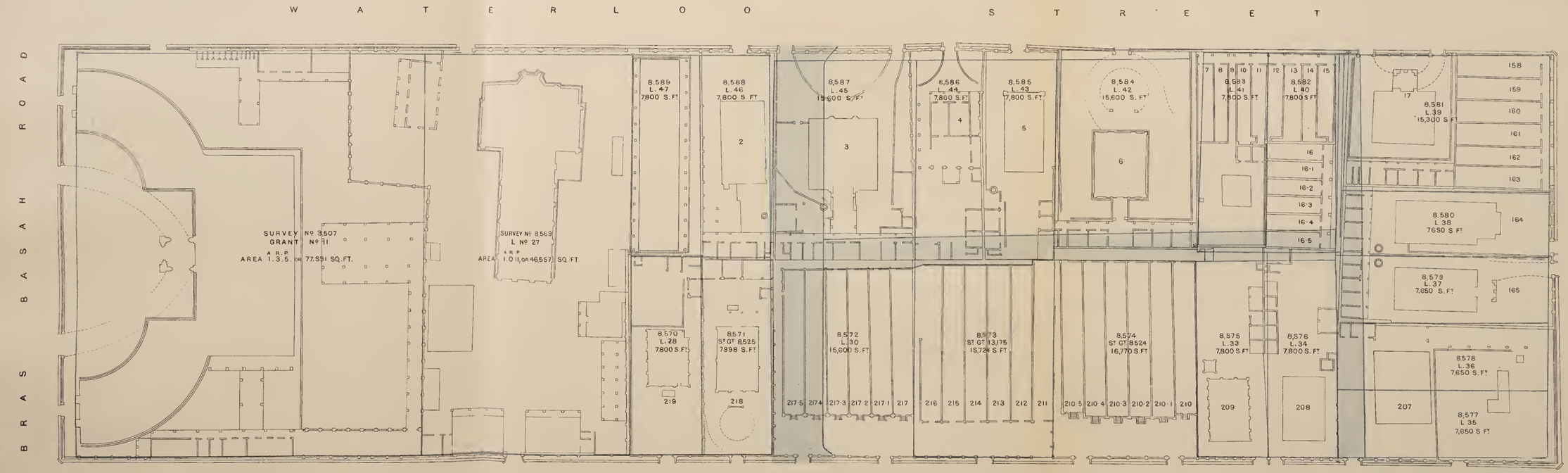
PLAN OF PROPOSED IMPROVEMENTS.

SCALE, 66 FEET TO 1 INCH.

PLAN XXII



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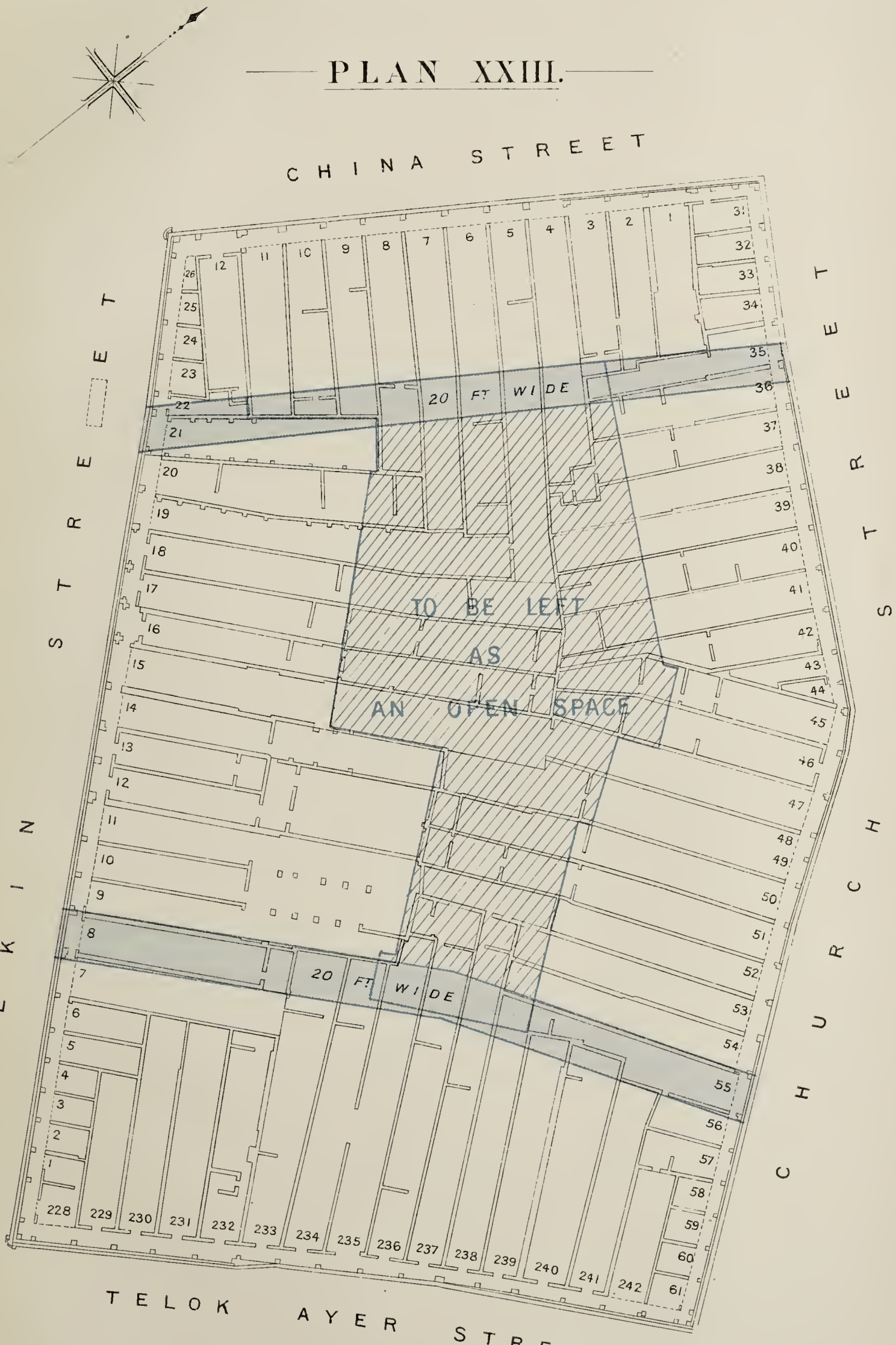
PLAN OF PROPOSED IMPROVEMENTS.

— SCALE 66 FEET TO 1 INCH. —

— PLAN XXIII. —



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In matters affecting Penang, the Health Officer of Penang and the Municipal Engineer of Penang would take the place of the Health Officer of Singapore and the Municipal Engineer of Singapore.

Further, seeing that there is no one on the Council to advise the Governor on sanitary matters, hospital administration, quarantine, and the general medical work and medical legislation of the Colony, it is desirable that the P.C.M.O. should be placed on that Council. He would then be in a similar position to the P.C.M.O. of Hongkong, whom it was found necessary to place on the Council.

37. Objects and reasons for suggested amendments to bill.

If a Sanitary Board is created as suggested, I would recommend several amendments in the Bill intituled "An ordinance to provide for the abolition of unhealthy dwellings, and for the sanitary condition of the town."

The object of these amendments is, first to secure qualified officers for the necessary enquiries and for the consideration of the schemes, and secondly to provide a machinery which will simplify and expedite the working of the Acts, and do so without there being any chance of it being brought to a standstill. Many of the difficulties and delays which have arisen in England in the working of the housing of the Working Classes Act have been due to magistrates unfamiliar with the subject holding their own peculiar views as to what is healthy or unhealthy, and what is fit or unfit for human habitation. It is now felt by those authorities who have had much experience in the working of the Act—among whom I may mention Sir Shirley Murphy, Medical Officer of Health for the County of London, whose experience has been unique on housing questions, and with whom I have taken the opportunity of discussing the subject that the agency should be administrative rather than legal—that there should be a special court on which the medical side of the question is duly represented, to deal with unhealthy houses and unhealthy areas, and that the court for assessing compensation should be similarly constituted, in order that valuations by surveyors and others should be taken at a sanitary estimate, and insanitary buildings not over estimated in value.

It is also felt that the usual additional compensation of 10 per cent. for any building that is not insanitary is a mistake, and that if an owner receives the value for his property there is no reason, further than a possible sentimental one, that he should receive more.

Suggestions Relating to Part I.

Unhealthy Areas.

In Clause 6, Section 3, instead of "by such officers as he shall appoint," insert "by at least two members of the Sanitary Board, one of whom shall be the P.C.M.O." The section would accordingly read:—"If on consideration of the petition and on proof of the publication of the proper advertisements and the service of the proper notices the

Governor in Council thinks fit to proceed with the case, he shall direct a local enquiry to be made by at least two members of the Sanitary Board, one of whom shall be the principal Civil Medical Officer, for the purpose of ascertaining the correctness of the official representation made as to the area, and the sufficiency of the scheme provided for its improvement, and any local objections to be made to such scheme."

In Clause 13, Section 2, add "Sanitary" before Court. It will then read "On the occasion of assessing the compensation payable under any improvement scheme in respect of any house or premises situate within an unhealthy area, evidence shall be receivable by the Sanitary Court to prove."

In Clause 15, Section 2, substitute "two or more members of the Sanitary Board, one of whom shall be the principal Medical Officer," instead of "such persons," and "Sanitary Board" instead of "such officers as he shall nominate for the purpose." The section will then read: "If after local enquiry by two or more members of the Sanitary Board, one of whom shall be the principal Civil Medical Officer, as may be appointed by the Governor in that behalf, the Governor in Council is satisfied that an improvement scheme ought to be made in respect of such areas, the Governor may forthwith direct that an improvement scheme shall be prepared by the Sanitary Board and shall be submitted to the Legislative Council."

Suggestions Relating to Part II.

Unhealthy Dwelling Houses.

In Clause 19, Section 1, delete "under the Municipal Ordinance, 1893," and add "The Court, hereinafter referred to as the Sanitary Court, shall consist of two or more members of the Sanitary Board, one of whom shall be the principal Civil Medical Officer."

In Section 2, substitute "Sanitary Court" for "Police Court." The section will then read: "Any such proceedings may be taken for the express purpose of causing the dwelling house to be closed whether the same be occupied or not, and upon such proceedings the Sanitary Court may impose a fine not exceeding two hundred dollars and make a closing order."

In Clause 20, Section I, add "constitutes a public nuisance or" before "is dangerous to health."

The section then reads: "Where a closing order has been made in respect of any dwelling-house, and has not been cancelled by a subsequent order, then the Municipal Commissioners, if of opinion that the dwelling-house has not been rendered fit for human habitation, and that the necessary steps are not being taken with all due diligence to render it so fit, and the continuance of any building being or being part of the dwelling-house constitutes a public nuisance, or is dangerous or injurious to the health of the public or to the inhabitants of the neighbouring

dwelling-houses, shall pass a resolution that it is expedient to order the demolition of the building."

In Section 3, instead of "then unless an owner undertakes to execute forthwith the work necessary to render the dwelling-house fit for human habitation the Municipal Commissioners," substitute "they," and after "building" add "Provided that the Municipal Commissioners may adjourn the hearing of the case if they think fit to do so, to enable the owner to execute within such time as they may determine the works necessary to render the dwelling fit for human habitation."

The section would then read, "If upon the consideration of the resolution and the objections, the Municipal Commissioners decide that it is expedient so to do, they shall order the demolition of the building. Provided that the Municipal Commissioners may adjourn the hearing of the case if they think fit to do so to enable the owner to execute within such time as they may determine the works necessary to render the dwelling fit for human habitation."

Section 4. With the alteration made in Section 3, Section 4 may be deleted altogether.

Clause 21. In Section 2 add "or which does not comply with the law relating to the erection of new buildings," after "which will be dangerous or injurious to health," also delete "all or any part of" and instead of "abate the same, &c.," substitute "make such building conform to the building laws, and in the event of the owner failing to comply, the Municipal Commissioners may order the demolition of the building."

The section would then read: "Where a building has been so taken down, no house or other building or erection which does not comply with the law relating to the erection of new buildings shall be erected on the site of such building; and if any house, building or erection is erected contrary to the provisions of this section, the Municipal Commissioners may at any time order the owner thereof to make such building conform to the laws, and in the event of the owner failing to comply, the Municipal Commissioners may order the demolition of the building."

Clause 22. Section 1. Instead of "Bench Court" substitute "Sanitary Court."

The section will read: "Any person aggrieved by an order of the Municipal Commissioners under this part of this Ordinance may appeal against the same to the Sanitary Court, and no work shall be done nor proceedings taken under any such order until after the appeal is determined or ceases to be prosecuted."

Clause 25. In Section 6, before "will be dangerous, or injurious to health," insert "does not comply with the requirements of the building or which."

Clause 26. Section I. (*b*). Before "that the closeness, narrowness and bad arrangement" insert "on the representation of the Health Officer." This provides a moving force, and prevents this section becoming a dead letter.

In the same section, at the end, after "the improvement of the said area" add "and such scheme may provide for the inclusion of neighbouring lands."

This is the same provision of power, to include neighbouring lands, as is given by Section VII. of the Housing of the Working Classes Act of 1903.

Clause 26. Section I. will now read as follows :—

"In any of the following cases, that is to say :—

(*a*) Where an order for the demolition of a building has been made in pursuance of this part of this Ordinance, and it appears to the Municipal Commissioners that it would be beneficial to the health of the inhabitants of the neighbouring dwelling houses if the area of the dwelling house of which such building forms part were used for a highway or open space ; or

(*b*) Where it appears to the Municipal Commissioners, on the representation of the Health Officer, that the closeness, narrowness and bad arrangement or bad condition of any buildings or the want of light, air, ventilation or proper conveniences or any other sanitary defect in any buildings, is dangerous or prejudicial to the health of the inhabitants either of the said buildings or of the neighbouring buildings, and that the demolition or the reconstruction and rearrangement of the said buildings or of some of them is necessary to remedy the said evils, and that the area comprising those buildings and the yards, outhouses and appurtenances thereof and the site thereof is too small to be dealt with as an unhealthy area under Part I. of this Ordinance, the Municipal Commissioners shall pass a resolution to the above effect and direct a scheme to be prepared for the improvement of the said area, and such scheme may provide the inclusion of neighbouring lands."

Clause 27 should be deleted altogether. The scheme was originally intended to deal with a few houses in back courts, &c., and the object was to relieve the authority of rehousing. It was only by accident Clause 27 crept in, and its effect has been to prevent Clause 26 from being much resorted to.

Clause 29. Section 2. Instead of "Police Court" substitute "Sanitary Court."

Section 3. Instead of "Police Court" substitute "Sanitary Court."

38. Site values and their assessment.

It may be useful here to refer to the exorbitant prices which the Municipality are asked when desirous of purchasing land for public purposes. The value of the land is immediately raised to quite a fictitious price, although it has been practically valueless before. There is an

immense amount of vacant land lying useless within the Municipality which is low rated. The question arises whether the Municipality should not acquire the power, as has been done elsewhere, to buy the land compulsorily at the value at which it is rated, and, in the case of an owner raising the value of his land to an unfair price, the land, in the event of failure of coming to terms, should be rated at the value put upon it at the time of the negotiations.

39. Bye-laws required for Malay huts.

The irregularity with which Malay huts and houses are built, and the construction of dark and unhealthy lower rooms which are not raised from the ground and not protected by proper plinths from being periodically flooded, contribute, in no small degree, to the formation of unhealthy areas.

These insanitary areas can be dealt with by the powers provided in the special ordinance, which has already been referred to, but, in addition to demolition and reconstruction, there require to be bye-laws, having special reference to huts, which, though on similar lines to those relating to domestic dwellings of a more substantial character, yet, owing to the huts being more limited in height and less closely brought together and better designed, need not be so stringent in their nature.

At present there are, apparently, no bye-laws specially relating to huts, and it is recommended that the following rules should form a basis for the control of huts in new and old Kampongs.

The following may be taken as a basis for bye-laws :—

1. Huts in a Kampong must be built in continuous lines in accordance with an alignment, in their front and rear, to be prescribed by the Municipality and demarcated on the ground.

2. Between all huts abutting on the roadways of a Kampong there must be a space of at least 6 ft. measured from eave to eave. This space, together with the backyard, may be enclosed by the respective owners by boundary walls not higher than 6 ft.

3. No street or road in a Kampong shall be of less width than 20 ft., and no back lane of less width than 15 ft., *i.e.*, in front of the hut there shall be a roadway of 20 ft. and behind the backyard of the hut a lane of 15 ft.

4. Every hut shall be provided with a properly constructed latrine, located in the backyard close to the back lane to facilitate its scavenging.

5. No hut shall comprise more than two stories or shall exceed 18 ft. in height.

6. The plinth of a hut shall be raised at least 2 ft. above the level of the centre of the road. When raised on piles, except when over water, the plinth shall be the same for the purposes of drainage.

7. No rooms shall be permitted to be constructed underneath the floor of a hut which has been raised on piles.

8. No brick domestic dwellings shall be permitted to be constructed in these Kampongs unless they are at least 20 ft. from the centre of the Kampong roadway, and conform in every respect with the ordinary building laws and bye-laws for domestic buildings in regard to back lanes, proportions of site uncovered, &c. The object of this is to secure roads of at least 40 ft. in width should all the huts be replaced by brick buildings.

40. Recapitulation.

To recapitulate. The remedies for the housing question in Singapore are :—

I. The introduction and enforcement of efficient building laws. The clauses suggested might be referred to the Attorney General for their phraseology to be put into proper legal form, and when so altered they should be added to the existing bye-laws and, if thought advisable, embodied in a Building Act.

II. The abolition of insanitary and congested areas. The opening up of the dark and ill-ventilated rears of back-to-back houses, and the demolition, partial or complete, of unhealthy and obstructive buildings would improve the ventilation of the houses and the block or area in which they are located, and would at the same time provide back lanes, which are necessary to secure efficient scavenging and a proper system of drainage.

The Bill, intituled "An Ordinance to provide for the abolition of unhealthy dwellings and for the sanitary conditions of Singapore," will provide the necessary powers. It will, however, have been gathered from the preceding report, that to deal effectively with the insanitary areas in Singapore, improvement schemes of considerable magnitude require to be devised and carried out, both in respect of land the property of the Crown and of freehold land. These schemes are far too large to be dealt with by the Municipality alone.

The improvement schemes in Bombay are carried out by an Improvement Trust, and, apparently, in Calcutta a similar agency is contemplated. These Trusts are distinct authorities from the Municipalities. In the case of the Bombay Trust the Municipality is represented on the Board, and a contribution of 2 per cent. on the rateable value is made by it annually to the finances of the Trust. As far as I was able to learn on a recent visit to Bombay, a conspicuous defect in the constitution of the Trust is the absence on it of expert medical and sanitary members. The result is that, although a vast improvement has been effected by the Trust, yet the full sanitary value for the money expended has not been always secured, and in several instances the buildings erected by the Trust hardly come under the category of sanitary buildings, though the air space around them is ample.

I visited some of these with Dr. Turner, the Health Officer of Bombay, who is not a member of the Improvement Trust. Another defect appears to be its too complete dissociation from the Municipality.

To avoid these two mistakes in Singapore I would suggest that for carrying out the improvement schemes, the Sanitary Board, with a constitution such as I have recommended, should work in association with the Municipality. A modification in the Ordinance should be made empowering the Sanitary Board referred to, to assist the Municipality in its schemes dealing with freehold property, while the Sanitary Board on the initiation of the Municipality, as provided in the Ordinance, might deal as a whole with properties of the Crown which are on a lease of 99 years or less. Fortunately, on most of this land it is only a matter of construction of back lanes, and probably the majority of the leaseholders would willingly agree to the necessary improvements being carried out at their own expense if they could be assured that by so doing their leases would be renewed for a longer period. Of course, any such agreement would not relieve them of conforming to the building laws and bye-laws.

III. The raising and draining of the land in the low-lying and insanitary Malayan Kampong, and the possible affording of assistance to the owners to rebuild their huts on regular and sanitary lines, also the prevention of new huts being erected on low-lying land without provision being first made to raise the land, also the enforcement of building laws relating to huts, are the methods by which healthy Kampongs can be secured.

IV. The preparation of extension plans within the Municipality would secure the laying out on sanitary principles of those parts of the town unbuilt on and enable the Municipality to exercise an efficient control over the opening up of new areas.

SEWAGE REMOVAL AND DISPOSAL.

41. High death-rate from bowel complaints.

The number of deaths from diarrhœa and dysentery and bowel complaints, generally, is very high considering the quantity and quality of the public water supply. The number gives an average death-rate of over 5 per 1,000 of the population. Wherever dysentery exists its prevalence has been proved over and over again to be due to defective arrangements relating to excrementitious matter, with its consequent contamination, directly or indirectly, of food or drink, and Singapore is no exception in this respect.

42. History of dysentery prevalence in the Alexandra barracks, and its cause.

A contaminated water supply, brought about by inefficient removal of excrement, accounted, during 1905, for the great prevalence of dysentery in the 95th Russell Infantry, a regiment stationed at Alexandra Barracks.

Alexandra barracks were erected as temporary barracks in 1903, the men's rooms consisting of Attap huts raised on brick pillars a few feet above the ground. The buildings are close to the War Department boundary line, immediately beyond which the ground is covered with jungle, polluted with the slop water from the barracks which finds its way into marshy ground below. A healthier and higher site was, apparently, reserved for the permanent barracks, which have still to be erected.

Half of the number of the latrines of the existing barracks were constructed immediately above cook houses and barrack rooms, and one, since removed, drained into the men's well a short distance below. Dysentery, more or less, prevailed during the first two years of the occupation of the barracks and culminated in 100 cases of dysentery in 1905, there being only one other case of dysentery among the Asiatic troops quartered in other parts of Singapore, where the water supply was not liable to contamination with fæcal matter.

With the removal of the insanitary latrines and the construction of new latrines on sanitary principles below the barracks so that there is no possibility of their contents overflowing and being carried, during heavy rains, into the well, the dysentery has practically disappeared. The wells, however, are not looked upon as safe by Colonel H. H. Johnstone, R.A.M.C., an opinion I endorse, and it is proposed to lay on Municipal water as soon as the pipes arrive from England. A contrast to the prevalence of dysentery in Alexandra Barracks is its absence at Tanglin Barracks, among the European troops, since the Municipal water was introduced. At first the Municipal water was brought to the barracks in carts, but since March, 1905, it is brought in pipes. While the Asiatic troops were there they appear to have continued the use of the wells.

43. Continued prevalence of dysentery in the jail and its causes.

The continued great prevalence of dysentery and diarrhœa, and the occurrence of typhoid fever in the jail, is also associated with defective arrangements for the removal of the excreta and the facilities it affords for the contamination of the drinking water; sometimes the greatest incidence of these diseases is on one grade of prisoners and sometimes on another, depending much on the extent of the infection in particular blocks. On the 6th of August, 1906, for example, there were in hospital 76 patients, or 8·1 per cent. of the total prison population, and of these 76 no fewer than 42, or 55 per cent., were middle-grade prisoners, although not more than 35 per cent. of the total population of the prison are middle-grade prisoners. Of these 42 patients two were suffering from typhoid fever, six from dysentery and 18 from diarrhœa, 26 in all, amounting to 62 per cent. of the total.

A careful inquiry into the history of these cases and their relationship with other cases in connection with food, water supply and excreta disposal made it evident that, though the food and water were good, yet the arrangements for collection and removal of the excreta from the jail were so defective that it was impossible for the infective dejecta to be at times prevented from infecting the drinking water, though it had been previously boiled. To this might be added occasional contamination of the cooked food.

In each prison cell of each block, which is three stories high and contains over 250 cells, there is a very insanitary night pail which the prisoner uses regularly. On the floor, usually beside it is the pail containing the drinking water, which has been boiled, and often the dish containing the food of the prisoner. At 6 in the morning 18 men bring

6 or 8 large tubs into the block and put them down in the central passage. They then enter the cells, bring out the night soil pails and empty their contents into the tubs which are then taken down to the depôt, not far from the workshops, and emptied into the night soil carts. The nuisance arising from the arrangements is very offensive. The night soil pails when emptied into the tubs are taken out of the block, washed with water and Jeyes' fluid and scrubbed with native brooms and exposed to the sun until 2 p.m., when they are returned to the cells. There are no numbers on the pails, so that there is little chance of them being returned to the same cell.

As regards Block D, which is occupied by middle-grade prisoners, and in which, at the time of my visit, there were so many in hospital, the night soil pails were washed on the South-west side of the block, but the water was obtained from tanks of Municipal water in the North-east side. This water was obtained by dipping pails into the tank, and was a very sure way of polluting the water. The dishes or tins which are used to hold the early breakfast of the prisoners are washed in these tanks.

The general cleaning of the block is done by a separate gang of men, some 16 in number. They are also the carriers of the food from the kitchen. They wash the tins after use and put them back into the cell until the morning, when the tins are filled with congee, which is served to the men at 5.30 a.m., before they go to the workshops at 6 a.m. Sometimes a prisoner, be he a cleaner and food carrier, conservancy man or ordinary workman, suffers from diarrhœa or dysentery several days before he reports himself. In case of one of the patients suffering from enteric he had been ill quite two weeks before reporting himself.

I have already recommended that the system shall be abolished. It was evident, from inspection, that the night soil pails were not properly cleansed and disinfected. It was evident also from the investigation that dysentery infected pails got mixed up with pails that were not infected, and when placed in a healthy man's cell and used by him, special facilities were afforded, particularly with men of uncleanly habits, for their hands becoming contaminated and the food or water, or both, infected. Small tin mugs were used for drinking, and those were filled by dipping the mugs into the pail of boiled water. The same arrangement was in the workshop. There was a vessel of water that was boiled and a tin mug above it, and if a prisoner wanted a drink he dipped the mug in the water to fill it. If he had been recently to the workshop latrine, on account of diarrhœa or dysentery, there was very considerable risk of him contaminating the water by his hands in the process of dipping. There is no reason why Municipal water should not after rough filtration be brought by a pipe into each of the workshops, and on this pipe a Pasteur Chamberlain filter and tap be fixed, so that filtered water can be obtained from the tap direct. This would at least remove the risk of the existing system so far as the workshops are concerned. As regards the cells, the use of the pail as a vessel for storing water should be done away with and a covered teapot kind of vessel might be substituted, so that the

water could be poured into the mug without any resort to dipping. These changes will lessen the chances of contamination if, at the same time, the tanks for the washing of the food dishes are not used also to supply the water for cleansing the night soil pails; but the real remedy necessary to abolish dysentery and other enteric affections is a radical reform in the sewage disposal. Latrines should be built outside each block as a preliminary measure, and arrangements made for the prisoners using these latrines night and morning, and vessels for urine only placed in the cell. When a drainage system is introduced into Singapore these latrines should be converted into water latrines and connected with the sewerage system of the town. The surface and underground drains of the jail, which receive the washings from the night soil pails and the drainage from the hospital, would then cease to discharge into the open surface drain of the road outside the jail.

The two instances given refer to bodies of men on whom the incidence and spread of dysentery and diarrhœa can be more or less clearly followed. The cases are traceable, and the conditions which give rise to the diseases are evident.

44
Dysentery among the Civil population.

Turning now to the civil population of Singapore, it is seldom that any information is obtainable regarding sickness from any particular disease. That is the great difficulty in tracing case after case of sickness, but to make up for this defect there is no difficulty whatever in showing that the same conditions which have given rise to dysentery in the Alexandra barracks and the jail, and are the conditions which are found to be associated with this disease, and with all enteric diseases whenever they have been enquired into, under more favourable circumstances, also exist very abundantly and generally in Singapore. Excremental pollution, owing to defective sewage removal, is common.

45.
Polluted wells.

It may be mentioned that there are at least 4,000 wells in Singapore, of which the majority are sewage polluted.

In the year 1902 a return of the existing wells was made, and it was shown that within Municipal limits there were 3,877 wells; of these it was reported by the Health Officer that 609 possibly contained good water and the remainder were obviously bad.

In 1905, Dr. Finlayson, the bacteriologist, examined 105 wells, and reported that only five were found to contain water which could be consumed with safety, and that the remainder "could not be held as otherwise than merely more or less diluted cesspools."

The existing arrangements for removing night soil and cleansing of the latrine buckets in the house afford facilities for the pollution of wells by excreta, and at times by infective matter. The channels of pollution and infection are usually by soakage into the well from the drain or surface, and by dipping of buckets into the well for water to cleanse the excreta pail.

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There can be little doubt that if the wells and tanks, which are all more or less contaminated, were filled up so that water from them could

not be used and drank and the Municipal filtered water were laid on instead in the different localities and houses which these wells and tanks supply there would be a very appreciable decline in the prevalence and death-rate from cholera, dysentery, enteric fever and bowel complaints.

47. Power required to prevent the reopening or digging of wells.

It is not sufficient to close the wells, but it is also essential to keep them closed and prevent any new ones being dug without the consent of the Municipality. There is no law forbidding the digging of a well or the making of an excavation without permission of the Municipality. The Health Department can only deal with wells and tanks and pools and ponds after they have been proved to be a nuisance. The Health Department can be engaged closing wells, while the people generally may be equally busy digging wells and making excavations.

48. The filling up of wells only a partial remedy.

The filling up of the wells and the supply of filtered water will effect only a partial removal of the conditions productive of dysentery and other bowel complaints. They leave untouched the existing method of sewage removal and its dangers.

49. Cholera spread in other ways than by the wells.

In this connection it has been found by the Sanitary Department that though a number of cholera cases in the town this year, and in former years, were, apparently, attributable to contaminated water from wells which were the subject of gross pollution, yet many secondary cases occurred in houses provided with Municipal water and appeared to be accounted for by direct infection. There is no aerial infection in cholera. The only channel by which that infection gains an entrance into the body is by the mouth. It is a case of either eating or drinking something which contains cholera germs, and it is these micro-organisms, producing in the intestines of the infected person toxins or poisons, which are absorbed into the general circulation, that cause the symptoms of cholera, accompanied by violent intestinal discharges. It is in these intestinal discharges the cholera germs make their exit from the body and they can only reach the intestines of another healthy person by some of this fæcal matter containing them being swallowed. It is generally a case of contamination of food or drink or both by fæcal matter.

50. The existing methods of sewage removal are well adapted to contaminate food and drink.

The facilities afforded for contamination of this kind will be obvious when the existing methods of the removal and disposal of the sewage in Singapore are examined.

51. Description of existing methods in private houses, Chinese, and others.

It will be seen from the plans of the back-to-back houses already described that the latrines are with the kitchen in the back area, which may be partially open, and that there are generally latrines for each storey. The coolie enters the front door with his bucket, goes to the latrine, empties the solid contents of the night soil pail into the bucket, washes out the pail and pours the washings down the surface drain, by which they flow slowly through the lower rooms of the house to the front door, where they discharge into the surface drain of the street. Having finished with the latrine on the lower floor he proceeds upstairs to that on the second floor and repeats the process. This time the

washings of the pail enter an iron pipe which discharges its contents into the surface drain on the lower floor. Not infrequently there is no pipe, or it is broken, but the sewage is expected to find its way all the same to the surface drain. And so it goes on until the latrines on all the floors have been attended to. The sulliage from the kitchen and the bathrooms is discharged by the same channels. The coolie then leaves by the same entrance as he came. The nuisance inseparable from such a method need not be dwelt on. The risk to contamination of Municipal water laid on to the house is accentuated by the Chinese custom of storing their drinking water in barrels and ladling it out when wanted. This storage is partly due to scarcity and partly to the desire to allow the suspended matter in the water to deposit.

52. Removal of sewage in European houses.

Even in the European quarters of the town the arrangements for removal of sewage are most unsatisfactory. The contents of the commode are emptied into the latrine situated in the servants' quarters, and the coolie empties and cleanses the pail in the servants' latrine much in the same way as has been described, with the result that the washings either pass into a surface drain, which may or may not terminate in the road drain.

53. Conditions existing in a house in which typhoid fever occurred.

The risk involved by these primitive arrangements, quite apart from the nuisance, was well illustrated in a house situated beyond the Municipal water supply, where a case of typhoid fever occurred. There were two wells, one was much polluted and was not more than a dozen feet from a public road and subject to be flooded with water from the road drain. It was stated not to have been used for some time, which may or may not have been correct. The other well had a good parapet and was excellently paved, but the water was obtained by dipping two buckets down into the water. The same man who emptied the commode into an insanitary latrine and washed out the commode vessel also drew water from the well for the kitchen and house. The latrine was close behind the cook house, the urine overflowed from a cesspit on to the ground, and as the commode and latrine pail were washed over this cesspit the sewage flowed down from it to a foul pit some yards distant, where it was intended to sink into the ground but, as a matter of fact, formed an open cesspool.

54. Removal of sewage by private contract renders preventive measures difficult in typhoid and other infectious cases.

Owing to the removal of the night soil being a matter of arrangement between the householder and farmer, and not a Municipal affair, it happens when a case of typhoid or dysentery occurs in a house that no special arrangements are made to secure that the infective discharges from the bowels, and the infective urine, are thoroughly disinfected and received in specially marked receptacles and that the contents are dealt with separately, and that the receptacles are always disinfected and replaced by clean ones. The result is that there is great risk of the coolie, who comes on behalf of the farmer to collect the excreta, and who visits several houses for that purpose, conveying the infection by means of his pails to the latrines of neighbouring houses, and then it depends on time, circumstances and susceptibility as to whether any of

the inmates of that house shall be infected through the relationship of the Tokang Ayer, or water carrier, with the latrine, cook house, bath-room and water supply. Much of the risk could be removed by extending to these houses the Municipal water supply, but it would not completely remove it, for there came under my observation cases in which the spread of infection and continuance of secondary cases seemed to be directly attributable to the insanitary method of sewage removal.

55. Servants' quarters frequently in a very insanitary condition.

The insanitary condition of the servants' quarters, especially in connection with sewage removal and drainage and the liability on account of these of pollution of food and water, were very noticeable in houses in which typhoid fever had occurred. In one house with Municipal water the drainage passed down close to a well and polluted it, and next the well, and partly choking the drain was a rubbish heap, which was spread over an area of 20 feet square and swarming with flies. This rubbish heap was at the door of the kitchen, the cooked food in which was exposed to flies and dust. The same bucket was used for carrying the Municipal and the polluted water.

56. A case of typhoid fever caused by falling into a surface drain.

That the open drains are sometimes not free from infective matter follows from their receiving the drainage from infected houses. An instance of probable infection from an open drain came before me in the course of my inquiries. It was that of a little girl attacked with typhoid fever. After careful investigation of the cause and the exclusion of all other sources, such as infection by milk, food, water, flies, dust and personal contact, I was unable to come to any other conclusion than that the probable cause was her falling into one of these surface drains. Although she had a bath immediately after the accident she fell ill with typhoid fever in a little less than a fortnight. The girl in falling into the drain had received some of the material into her mouth.

There are other conceivable ways in which an infected drain may occasionally cause infection without infecting food and water directly or indirectly by flies and dust. With typhoid material in the drain, subject to moisture and dryness, it is not impossible, though probably very unusual, for the pneumonic form of typhoid fever to be produced by inhalation of the dust from the sides of these open drains.

57. Removal of sewage from the larger institutions.

From the larger institutions, such as the General Hospital and the jail, the excreta are removed in large carts. The emptying of the utensils or tubs into the carts creates a most sickening nuisance which, in the case of the hospital, is very reasonably complained of by the nurses near whose quarters this operation goes on. Wherever carts have to be used a similar nuisance exists. These and the pails, however, only take away the greater part of the solids and a portion of the urine. It is impossible for the coolie to resist the temptation of pouring away some of the urine into the surface drain. But even if he were to carry away all the solids and liquid found in the latrine, yet, owing to the latrine pails being cleansed at the time and the washings poured into the surface drain, it would not do away with the stench arising from these cleansings or prevent the

surface drains from becoming open sewers. The nuisance created during these operations has, on occasions, become so accentuated on sultry nights that it has awakened people from their sleep in buildings where they were being carried out. The smell of fœcal matter and urine is very strong in Singapore, not only in a large number of the houses but also in the morning in the streets.

The cleansing of the public latrines by the Municipality gives rise to a similar nuisance, which is much complained of by the inhabitants in their vicinity.

58. Summary of the different methods of removal and disposal of the sewage.

The sewage which is collected is removed and disposed of as follows :—

I. That from the public latrines is removed, in the pails which have been used, in carts, and is taken to cocoanut plantations outside the town. This is done by the Municipality. A small portion is taken to vegetable gardens within the town.

II. That from the hospital, jail, and Government buildings is removed by private contract in barrel carts by a private contractor, and is also taken to cocoanut plantations outside the town.

III. That from the barracks is removed by private contract in buckets, and disposed of on vegetable gardens within the town.

IV. That from private houses is removed by private contract in pails, and either taken direct to vegetable gardens, maggot breeding places for duck feeding, or it is taken in pails to the depôts, emptied into barrel carts, and then taken to cocoanut plantations and vegetable gardens outside the town.

59. No objection to sewage disposal on plantations.

There is no objection to the disposal of the sewage on cocoanut plantations if arrangements were made at convenient places for properly constructed depôts to cleanse and disinfect the pails, barrels and carts. The absence of these causes the coolies to cleanse the pails in the nearest stream or ditch.

60. Unsatisfactory condition of the utensils and carts, by which the sewage is removed.

There is evidently no supervision, or if there is any supervision, it is inefficient, in the removal and disposal of the sewage. A day's inspection on the road to the plantation, of the carts and pails, disclosed a most unsatisfactory state, with nearly 40 per cent. of the pails leaky.

The following notes will afford some explanation of the nuisance arising from these carts passing through the principal streets of the town.

Municipal Cart No. 10 is a dilapidated two-wheeled cart with part of one side wanting, with a board wanting at the back and also part of the bottom wanting. It contains 15 buckets, eight of which were leaking and their contents escaping on to the ground ; three had lids and the rest were covered with ashes. An examination of these buckets after their contents had been discharged at the cocoanut plantation, and they had

been washed, showed not only eight broken and leaky but three of these with their bottom nearly out. The cart came from the public latrine in Havelock Road.

Municipal Cart No. 11 is a two-wheeled open bullock cart covered with tarpaulin. It is not so dilapidated as No. 10, but the whole of the bottom of the cart is covered with night soil which is leaking into the road. There are 14 buckets, only three have lids. All the fourteen are overflowing and three are leaking. The cart comes from the public latrine at Tanjong Pagar and Dunlop Road.

Municipal Cart No. 9 is a two-wheeled bullock cart with springs and iron top, bottom and sides. It is quite low and an improvement on the other carts. It is divided horizontally, so as to provide for two tiers of buckets. Contains 11 buckets, three are covered, floor is covered with night soil, seven buckets are overflowing and four buckets are broken and leaky. The night soil on floor of cart is not leaking through. The cart comes from public latrine at Telok Ayer market.

Prison Barrel Cart 2,763 is overflowing, maggots falling out of barrel with the night soil, leaks at the back end of barrel.

Prison Cart 780.—Filthy, but not leaking; well sealed.

Prison Cart 3,682.—Very filthy, but not leaking; well sealed.

Barrel Carts 1,840, 2,290, 3,673, 3,844 and 3,852, from Trafalgar Street Depôt.—In good condition, well sealed, no nuisance.

The preceding carts were examined when full and when going to the plantations or vegetable gardens. The following were examined as they were returning accordingly empty :—

Municipal Cart No. V.—Improved pattern, contains 19 buckets, 9 are leaky, 3 lids, floor of cart leaky; the cart comes from Wayang Street public latrine.

Municipal Cart No. 2.—Improved pattern, contains 15 buckets; there are 4 good buckets, the other 11 leak, 3 lids, cart has a hole in the bottom; comes from public latrine, Cecil Street.

Municipal Cart No. 19.—Improved pattern, contains 17 buckets, 7 broken and leaky, 3 lids, cart not in good condition but not leaky; comes from Pagoda Street and Almeida Street.

Municipal Cart No. 7.—Old pattern, two-wheeled cart with wooden sides and bottom and tarpaulin as cover; the wooden floor is saturated; contains 17 buckets, 6 broken and all badly washed, 7 lids; cart from public latrines at Hong Line Quay and New Market Road.

Municipal Cart No. 1.—Improved pattern, 2 tiers; cart leaky at side, 13 buckets, 5 broken and leaky, no lids; cart comes from public latrine at Kallung Road and Weld Road.

Municipal Cart No. 6.—Old pattern, plank bottom, saturated and leaking; 15 buckets, 5 broken and leaky, 3 lids.

Municipal Cart No. 17.—Improved pattern, cart in good condition; 13 buckets, 4 broken and leaky, 6 lids; from public latrines in Beach Road and Clive Terrace.

Municipal Cart No. 18.—Old pattern, good plank bottom and sides; 17 buckets, 2 leaky, 1 lid; cart comes from public latrines, Orchard Road and Waterloo Street.

Municipal Cart No. 16.—Old pattern cart, wooden sides and wooden bottom; condition good, bottom of cart wet; 20 buckets, 9 broken and leaky, 6 lids.

61. Disposal of sewage on vegetable gardens objectionable.

The removal of the sewage in pails by men to the vegetable gardens is not nearly such a nuisance as that created by its removal in bulk in the carts, but its disposal on the vegetable gardens is not nearly so satisfactory as its disposal on the cocoanut plantations. By the latter method of disposal there is no risk of contaminating edibles. By the former method, however, very great risk is incurred of contaminating vegetables with ova of parasites and with infective matter owing to the practice of the Chinese diluting the sewage with water and then sprinkling the mixture over the vegetables, which, of course, is very different from manuring the soil only.

62. Flies and nuisance, chief objections to maggot breeding within the town.

The main objections to maggot breeding from night soil being carried on within the town are the offensive smells which arise from the places in which it is conducted, and which travel a considerable distance, and the swarms of flies which are to be found on and near the night soil pits before the appearance of the maggots, and which may infect food in huts or houses close by. The pits are about 9 ins. deep and 5 ft. square. Into them the night soil is poured, minus the urine, and fresh material is added until the maggots appear in large numbers.

The process is completed in about eight days, when the pit is one mass of moving maggots living on the night soil. From then until the fifteenth day the Chinaman is busy taking out the maggots, washing, sorting and packing them in tins, when they are ready to be taken to the duck farms as food for the ducks.

63. The existing open drains are practically open sewers.

It has already been stated that much of the sewage, minus the greater portion of the solids, passes into the open drains of the street or road from private houses. It is the same from larger buildings. The drainage from Fort Canning containing slop, ablution water and a portion of the urine with washings of latrine pails and floors of latrines, empties into a concrete catchpit on the west slope of the hill from which it discharges on to the ground forming a polluted marsh a short distance above the site of the dwellings of the railway employées. It is the same with the drainage from the prison, asylum, hospital and Tanglin Barracks. It cannot be otherwise with the present arrangements. The drainage must either form

a polluted marsh a little way outside the premises of the buildings, or it must be led away by surface drains and find its way into the rivers and canals or into some of the numerous marshes in Singapore. The mistake is to suppose that because the greater portion of the solids is taken away in carts and pails, the remainder of the drainage is not sewage. Simple inspection is enough at times to establish the fact that it is sewage, and sewage of a gross character, chemical analysis is not required, sight and smell are sufficient in the case of Singapore drainage. But in order that the evidence should not be wanting in any respect, analyses were made by the Government analyst of samples of water taken from three drains, and the results showed the samples to be sewage.

64. No system of sewage removal, except by underground drains, is adequate for a town of over 200,000 inhabitants.

No system of sewage removal by means of manual labour and cartage is adequate for a town of over 200,000 inhabitants. A town of this size, and especially one which is growing so rapidly, must face the cost of the introduction of a sewerage system if it is to retain and improve in health and bring itself into line with the comforts of a modern city. There are difficulties to be overcome in introducing a sewerage system into Singapore, not in the European quarters or in the hotel district, but in those quarters which have been described, where the houses are back to back and there are no back lanes. The construction of these back lanes require to go hand in hand with the introduction of a sewerage system in these quarters, and, until the back lanes are constructed, the sewerage system can only be introduced into these crowded parts in a modified form which combines removal by manual labour as well as by means of sewers.

65. Reasons for the separate system of sewerage.

In introducing a sewerage system into Singapore, the cardinal principle for guidance is that it must be on the "separate system."

The sewerage should only deal with the sewage and sulliage water, and should leave the surface drains to cope with the storm water.

By separating sewage and storm water, the sewers can be so constructed that they shall be small. It avoids the costliness of large sewers, it also prevents the nuisance which invariably arises in the tropics from large sewers, and it does not attempt the impossible, viz., the removing entirely and quickly without flooding by underground drains the large volumes of storm water which have to be disposed of after heavy tropical rains. The separate system is the only feasible one for a town with an annual rainfall which exceeds in some years 100 inches.

66. The storm water drainage being provided, a drainage system for sewage on the Shone system is recommended.

A storm-water system of drainage has already been provided for in the surface drains which discharge into the rivers and sea. The system, with improvements, is effective enough for this purpose, but it has been rendered a nuisance by its employment also as a drainage system for sewage, and, as has been shown, a most inefficient one. The storm-water system in Singapore cannot be sanitarily combined with a sewage system, whether the drains are open or closed. The two must be separate. To remedy the condition of matters in Singapore the separation has to be made. It is requisite to relieve the surface drains of sewage, and allow

them to revert to their proper functions of storm-water drains, and to introduce a new drainage and sewerage system which shall carry only sewage and no rain water. A sewerage system is quite feasible in Singapore. The water supply is to be 35 gallons a head per day, which is more than ample for flushing purposes. Certain objections have been raised as to the introduction of an underground system of drainage. They are (1) the flatness of the site of the town; (2) the nature of the subsoil; (3) the fact that when underground drains were laid from the cricket club to the sea, in the course of three years they were choked up with roots of trees; and (4) that the Asiatic population use shells, sand, &c., in connection with their domestic cleaning, ablutions and sewage disposal habits. These and their like are very familiar objections, but are easily met. The flatness is overcome by introducing the Shone system of sewage, which can send sewage uphill if required. As regards the nature of the subsoil, this has already been tested by an extensive system of iron pipes for the distribution of the water supply of the town, which shows it also practicable to lay down under the same streets a system of pipes partly iron and partly stoneware on concrete for the collection of the sewage and the ejection of the same to one or to as many outfall tanks as may be required for its treatment and ultimate disposal either into the sea or on to land for irrigation purposes. The discovery of the roots of trees in drain-pipes from the cricket club only reveals bad workmanship. The same thing has occurred elsewhere, but it is always due to the same cause. No such incident need occur in connection with the laying of any of the proposed drains and sewers in Singapore if, as of course will be the case, the execution of sewerage works are entrusted to a responsible sanitary engineer.

With reference to the last objection, it may be stated that in Rangoon, where the Shone system of drainage has been in operation for twenty years, and where the same Oriental habits obtain as in Singapore, owing to the population being largely Chinese and Indian, the same objections were urged there originally, but all the difficulties prophesied turned out to be imaginary, and the system has proved to be practicable, efficient and elastic, and is now being largely extended to meet the rapid growth of the population which has taken place since it was installed there. The Shone system was also installed at Kurrachee, and there also it is being largely extended. It was also established in Colaba, Bombay, and afterwards introduced exclusively into other parts of Bombay. It has also been established in the low-lying part of Rio Janeiro and other tropical towns.

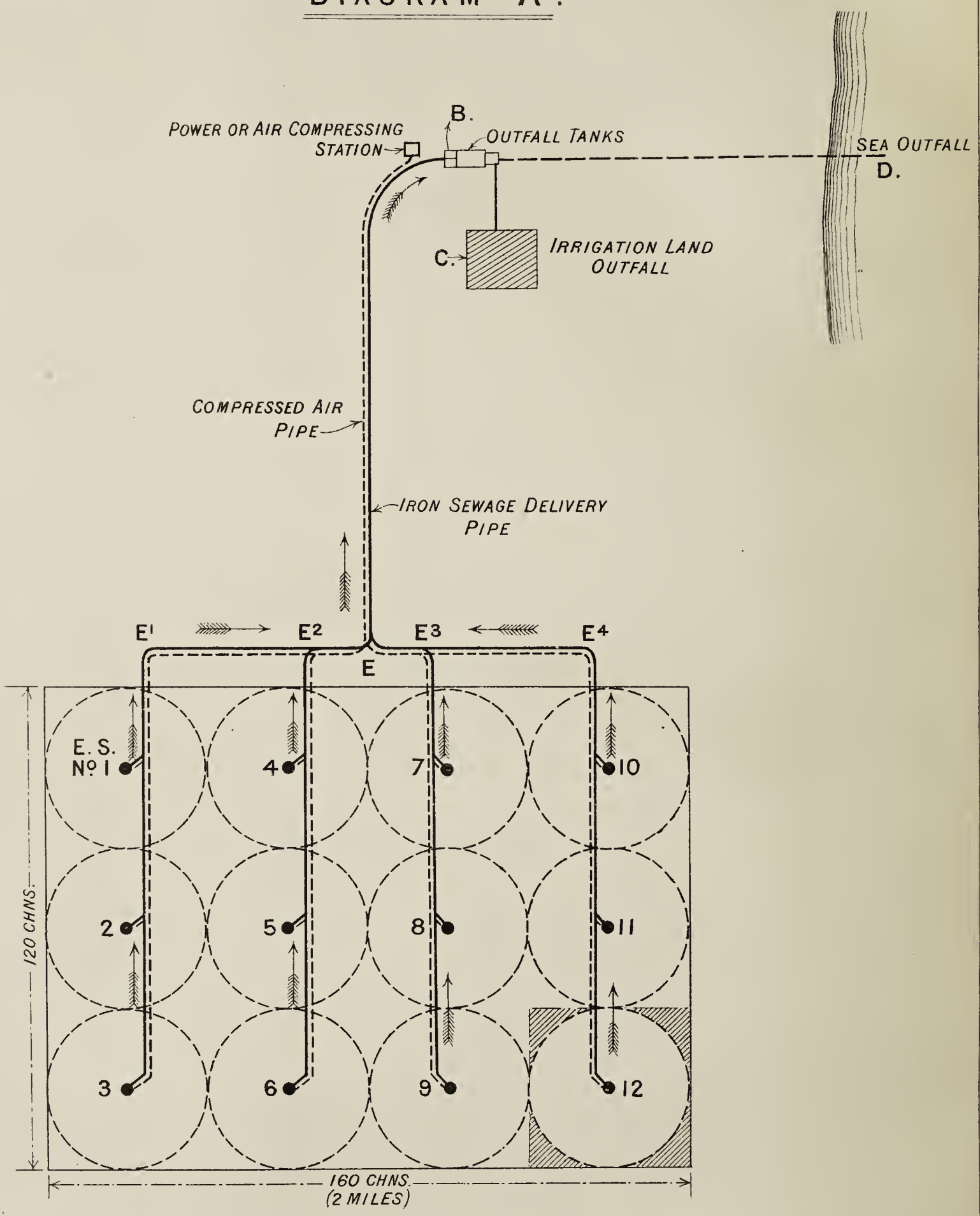
67. The advantages of the Shone system.

The advantages of the Shone system are that:—

(1) By its adoption proper scientific gradients for drains and sewers can always be secured, however unfavourable the configuration of the habitable areas may be. This is a very great advantage, for it enables engineers to design and lay down self-cleansing drains and sewers anywhere and everywhere regardless of surface or physical condition adverse to natural gravitation. In towns built as Singapore

SHONE HYDRO-PNEUMATIC SEWERAGE SYSTEM.

DIAGRAM A.



SCALE: 40 CHAINS = 1 INCH.

REFERENCE.

- ● E. S. — *EJECTOR STATIONS (Nos 1-12) PLACED IN CENTRE OF EACH DRAINAGE SECTION.*
- ——— *SEWAGE-DELIVERY OR IRON MAIN UNDER PRESSURE.*
- - - - - - *COMPRESSED AIR PIPES.*
- ⟿ *DIRECTION OF SEWAGE FLOW FROM THE EJECTORS TO THE OUTFALL; AND ALSO THE COMPRESSED AIR FLOW FROM THE POWER STATION TO THE VARIOUS EJECTOR STATIONS Nos 1-12 INCLUSIVE.*

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is, for the most part on flat, low-lying lands, it is impossible, in my opinion, either to design or construct water-carriage sewage drainage works which shall, after installation, be preserved permanently in a thoroughly sound and sanitary condition, without having recourse to mechanical contrivances which shall be equivalent in all essential respects to those which are now used in connection with the working of the Shone system.

(2) It can be laid down in districts and sections, and a district or section once completed can begin to work without waiting for the completion of other sections or districts. Each part of the town can thus be independently drained.

(3) Its power is derived from a single central station at which atmospheric air is compressed, and from which the compressed air is distributed to work the several district ejectors.

(4) The working of its sectional stations or ejectors is automatic, effected by compressed air from the central station, and requires very little personal attention.

(5) Its mechanism in every district is underground, and cannot be interfered with except by the officers responsible.

(6) The system of ejectors worked by compressed air is more sanitary than the ordinary steam power pumping stations with sump pits in which large volumes of sewage are necessarily stored, and where deposition of the solids in the sewage takes place, and where also extraneous material, such as rag, &c., accumulate and have to be periodically removed. I have also ascertained that it is more efficient in a mechanical sense. I am informed that the application of compressed air to the work of ejecting sewage on the Shone system for low lifts, up to from 25 to 30 ft., gives an efficiency of nearly 50 per cent., whereas the application of hydraulic power pumping sewage to the same heights gives from 16 to 20 per cent. at most.

(7) The Shone mechanical system of sewer ventilation with which the Shone system of drainage is associated, secures a thorough and efficient ventilation of the soil-pipes, drains and sewers, whether connected with the hydro-pneumatic system or the ordinary gravitation drainage.

68. The principles and details of the Shone system.

Diagram A illustrates in a simple manner the principles on which a district or town may be drained on the Shone system. In this diagram the ideal district or town consists of a plot of land 160 chains or two miles long, and 120 chains or one-and-a-half miles broad, containing 1,900 acres. It is divided into 12 drainage sections, in the centre of each of which is an ejector station. Each ejector station is fed by the sewage flowing down the gravitation sewers within each section, which converge to the manhole adjoining each ejector station, as seen in Diagram B. All things being

equal, therefore, each of the 12 ejector stations would receive and discharge the same volume of sewage per minute or per day, a condition of things which of course never occurs in practice. From each of the ejectors the sewage is discharged automatically by compressed air into the main iron delivery pipe, which conveys it to the outfall tanks B. After treatment in the tanks, the sewage can be delivered by gravitation direct into the sea to the point D, or by gravitation direct on to land to the point marked C for irrigation purposes.

If the water supply of this hypothetical town amounted to 30 gallons per head per day, this volume would also represent the sewage discharges per head per day from the population. Diagram B shows a section of an ejector station with its adjoining manhole.

How best to initiate a plan for draining Singapore on the Shone system falls to the province of the Engineer, but the accompanying drawing (Diagram C) shows six blocks of buildings in the town with their drainage and sewerage completed. It will be seen that the drainage from the house is taken into the back lanes recommended to be constructed in the housing portion of this report. The plan provides exclusively for the collection of the sewerage by gravitating drains and sewers into ejectors and for the ejection of the same into either a gravitation or pressure main sewer to be delivered finally into the outfall tanks for treatment before discharging on to the land or into the sea. The sewage of the subsidiary drains marked Nos. 1, 2, and 3 and Nos. 4, 5, and 6 respectively would flow into the main sewer marked No. 1, and then flow into the ejector station marked No. 1. The sewage of the other subsidiary drains marked 6, 7 and 8 would flow to the main sewer No. 2, and then flow into ejector station No. 2.

The sewage from ejector No. 1 would be ejected into an iron delivery pipe which would convey it to the outfall tanks, and the sewage of ejector No. 2 would also be ejected into the same iron outfall delivery pipe. A delivery pipe may be common to as many ejector stations as are required. The plan is practically the same as that adopted in the first instance for the drainage of Rangoon.

69.
A modified Shone system suggested until full scheme completed.

Until such a scheme can be completed probably some modification will have to be adopted. I do not favour the removal of the sewage by pails to two, five or more depôts, from whence it is to be ejected into the tanks of barges to be taken out to sea and there discharged. If such a system were extended to the whole of the town it would be as expensive as a complete drainage system, and it would not remove the objections to the existing arrangements. It would be a depôt system, only without means of converting it into an efficient drainage system. On the other hand, if the Shone system were decided on at once, and a plan for the whole town drawn out, it could be introduced in sections; which sections should have precedence is a matter for the Engineer to determine. It appears to me that the first proceeding would probably be the construction of an outfall on the Pasir Panjang Road, near Mount Faber where the sewage could be treated and purified and then discharged by gravitation

SHONE HYDRO-PNEUMATIC SEWERAGE SYSTEM.

DIAGRAM B.

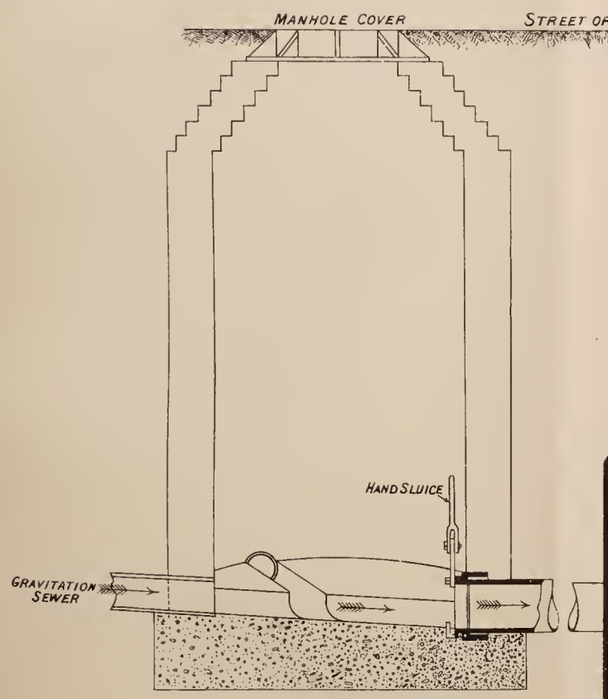

FIG. 1.

— MANHOLE. —

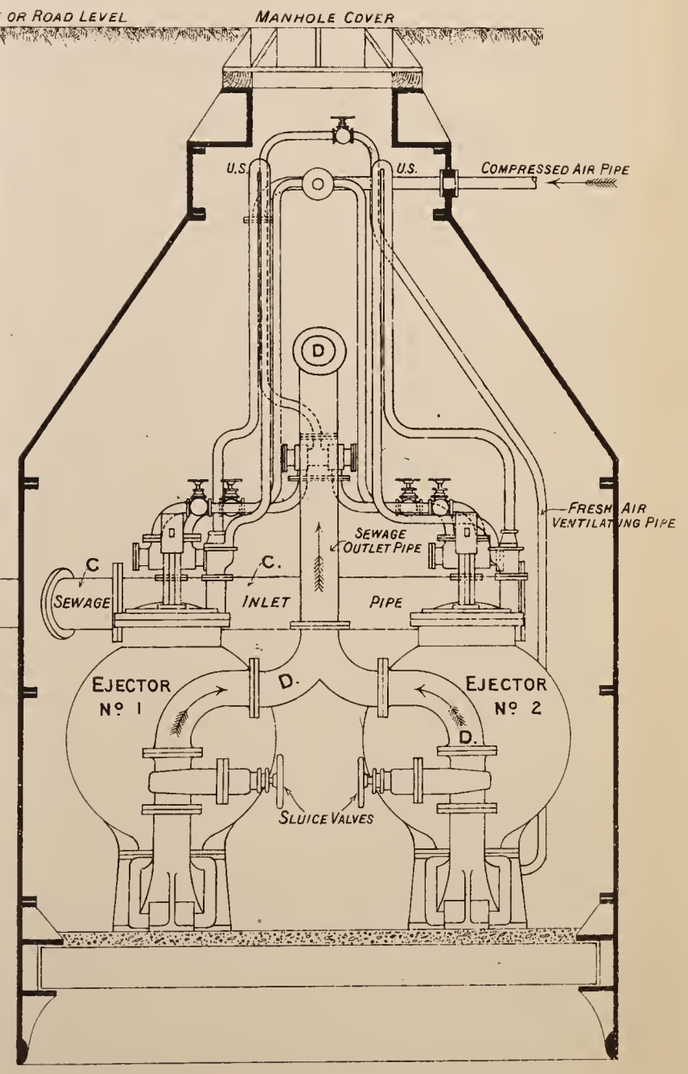

FIG. 2.

— EJECTOR STATION IN IRON TUBBING —

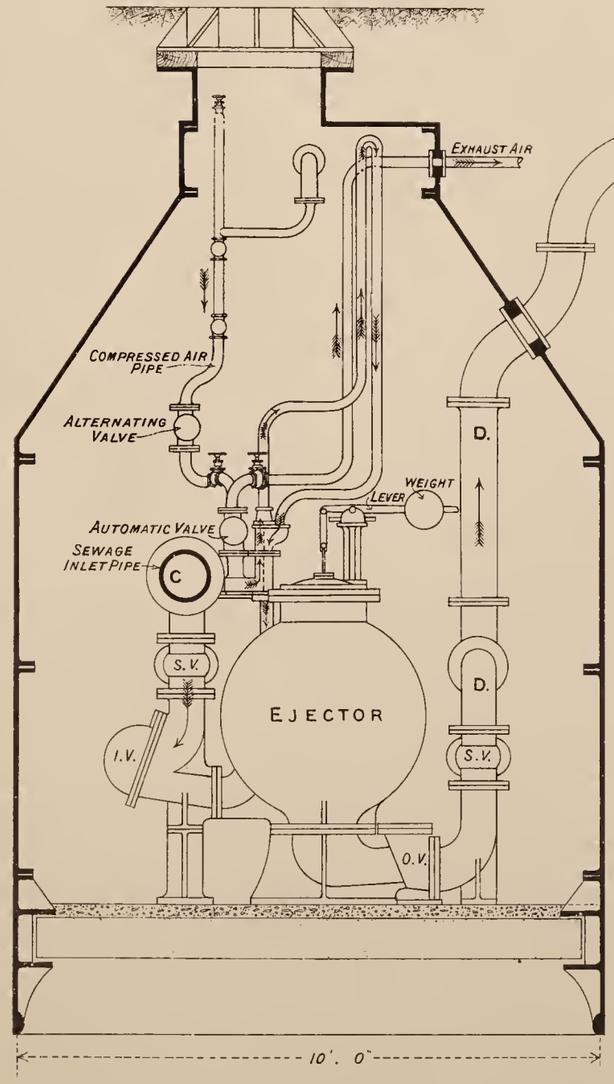

FIG 3.

— SCALE: 3/8 INCH TO ONE FOOT. —

C. ..... INLET.
D. ..... OUTLET.

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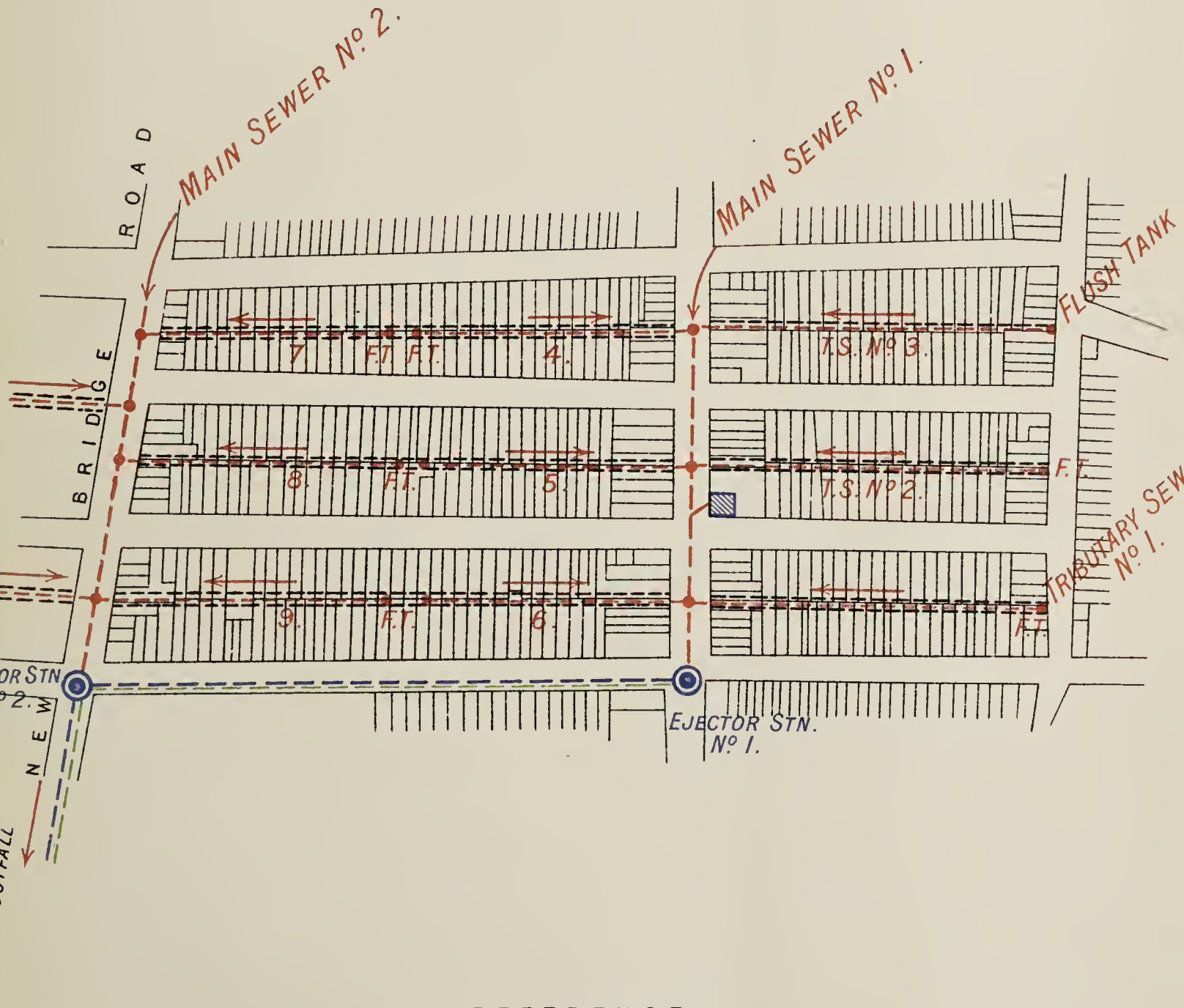
SHONE HYDRO-PNEUMATIC SEWERAGE SYSTEM.

DIAGRAM C.

SCALE OF FEET.

100 50 0 100 200 300 400 500 1000



REFERENCE

	INDICATES PUBLIC LATRINE.
	,, EJECTOR STATIONS.
	,, SEWAGE COLLECTING GRAVITATION SEWERS.
	,, SEWAGE DELIVERY MAIN.
	,, DIRECTION OF FLOW OF SEWAGE.
	,, PROPOSED BACK LANES.
	,, COMPRESSED AIR PIPES.
F.T.	,, FLUSH TANK.

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into the sea at the nearest point at all stages of the tide, or to land for irrigation purposes. The next would probably be the designing and construction of an intercepting sewer along New Bridge Road, Hill Street and Victoria Street, which would be either a gravitation sewer or pressure main as circumstances permitted. This would receive the sewage from the ejectors, which collect the sewage flowing within the areas on its right and left, and take it to the outfall. It would also receive, as soon as constructed, the sewage from the lunatic asylum, general hospital, prison, police station and offices, Fort Canning, the better class houses on the line of the road; the branch sewers from Bras Brasah Road and other parallel streets taking sewage from the hotels, schools and principal houses, the sewers from River Valley Road and other European quarters.

Public latrines are erected now along this main road, and they, with many more newly constructed ones, might be connected with this sewer.

70. Drainage should not be permitted underneath houses.

The introduction of drains into back-to-back houses should not be permitted, and until the necessary back lanes are provided, depôts for the disposal of their sewage would be necessary. To each public latrine connected with the main sewer a depôt should be attached. Into these depôts the contents of the pails would be discharged, and it would be in these depôts where the pails would be cleansed, disinfected and stored in order to be in readiness to replace the soiled buckets of the following day.

71. Gradual abolition of the pail system.

As the back lanes between the blocks are constructed, the drainage from the houses would pass immediately into them, and be connected, as shown in Diagram C, with the main sewer or sewers. The houses in such block would no longer require a pail system, and thus it would be that as the Shone system of drainage extended the pail system would be correspondingly reduced, and when the Shone system was completed the pail system would have been abolished.

72. Suggestion that Mr. Ault should be called in to draw up with Mr. Pierce a scheme of drainage on the Shone system.

If it is decided to adopt the Shone system of drainage, or any modification of it adapted to the local conditions of Singapore, I would recommend that Mr. Edwin Ault, a sanitary engineer of great experience, who is now in Rangoon, and who designed the Shone system there, and was responsible for the execution of the works carried out there, should be asked to visit Singapore, and, in conjunction with Mr. Pierce, the Municipal Engineer, draw out a scheme on lines similar to those suggested. It is essential that in drawing out a plan for the drainage of Singapore on the Shone system, the best and most experienced advice available should be obtained, and that can be secured by asking the assistance of Mr. Ault.

I have mentioned one septic or hydrolitic outfall purification tank on the Pasir Panjang Road, but it may be found advisable not to force the whole of the sewage there, but to divide the whole volume into three or four or more parts, corresponding to three or four or more drainage sections, and to eject the sewage of each section to a different covered and ventilated septic or hydrolitic tank situated in other parts of the Municipality.

RECLAMATION DRAINAGE AND DISPOSAL OF REFUSE.

73. Prevalence of Malaria in Singapore.

There can be no doubt that malaria prevails in Singapore. In 1905, Dr. Finlayson ascertained that out of 1,378 patients admitted for fever into the large native hospital in Singapore 52 per cent. had malarial parasites in their blood, and of 906 persons examined after death 11 per cent. died from malarial fever, and 40 per cent. had suffered from a malarial infection. Moreover, an examination by the same observer of mosquitoes collected from different parts of Singapore showed that there were at least a small percentage of malarial-bearing anophiles, and that the larvæ of different varieties were practically always associated with the larvæ of other genera. In 1904, Dr. Kirk made an analysis of 150 cases of local fever, which came under his and Dr. Galloway's observation during 1903 and 1904, and in 98, or over 65 per cent., the malarial parasite was present, and of these 48 were local infections and 50 imported.

While the Straits Chinese, immigrant Chinese, Malays and Indians are much subject to malaria, Europeans, it appears, enjoy a comparative immunity. The residential quarters of the latter are generally well away from the native, and it is to this fact, together with the use of mosquito curtains, that their immunity is more or less attributed.

That immunity, however, it is pointed out, is likely to disappear with the encroachment of native houses, especially shop houses, or in other words tenement houses, on those parts of the town now occupied by Europeans. This danger to the European community can easily be prevented when the Municipality is given power to specify the class of dwelling houses in special districts.

According to Dr. Kirk's experience, European children are not nearly so free from malaria as adults, and when they suffer it is from a severe type.

The prevalence of malaria, both in adults and children, is further supported by the answers given to a circular letter addressed to the principal medical men practising in Singapore. Their replies are in appendix B, page 135, and there is a marked unanimity on the subject.

The subjoined return of the number of the troops and their families treated for malaria at Singapore also furnish additional evidence of the prevalence of this disease, and it will be seen from the returns, in appendix A, of the sick statistics of the troops in Singapore during the eleven years, 1895–1905, that malarial fever accounts for at least one-third of the sickness of the soldier in the Straits Settlements.

RETURN OF CASES OF, AND DEATHS FROM, MALARIAL FEVER, AMONG THE TROOPS AND THEIR FAMILIES, AT SINGAPORE, STRAITS SETTLEMENTS, DURING THE SIX YEARS 1900–1905. (INCLUDES ALL CASES OF MALARIAL FEVER TREATED IN HOSPITAL AND BARRACKS.—H. H. J.)

EUROPEAN TROOPS AND THEIR FAMILIES.

Year.	Average Annual Strength.	Malarial Fever.				Remarks.
		Admissions.		Deaths.		
		No.	Ratio per 1,000 of strength.	No.	Ratio per 1,000 of strength.	
1900 ...	696	86	123·56	—	—	Case Mortality: 1 death in 1,018 cases, equivalent to 0·10 per cent.
1901 ...	487	76	156·06	—	—	
1902 ...	616	218	353·90	—	—	
1903 ...	988	732	740·89	—	—	
1904 ...	1,543	1,300	842·51	—	—	
1905 ...	1,669	643	385·26	3	1·80	
Total ...	—	3,055	—	3*	—	* 2 men. 1 woman.
Average...	1,000†	509	509·00	0·50	0·50	

† Warrant Officers, Non-Commissioned Officers and Men, 837 ; Officers, 44 ; Women, 43 ; Children, 76.

NOTE.—The excessive prevalence of Malarial Fever among the European Troops, in 1903 and 1904, was due to these troops having been encamped for field firing on exceedingly malarious sites at Bakit, Panjang, during these two years.

ASIATIC TROOPS AND THEIR FAMILIES.

Year.	Average Annual Strength.	Malarial Fever.				Remarks.
		Admissions.		Deaths.		
		No.	Ratio per 1,000 of strength.	No.	Ratio per 1,000 of strength.	
1900 ...	970	179	184·54	1	1·03	Case Mortality: 1 death in 149 cases, equivalent to 0·67 per cent.
1901 ...	1,186	231	194·76	—	—	
1902 ...	1,620	155	95·62	5	3·09	
1903 ...	1,044	131	125·48	2	1·92	
1904 ...	895	216	241·34	—	—	
1905 ...	1,013	278	294·80	—	—	
Total ...	—	1,190	—	8*	—	*8 men
Average...	1,121†	198	176·72	1·33	1·19	† Indians 997. Malays 120.

† Warrant Officers. Non-Commissioned Officers and Men, 1,027 ; Officers, 17 ; Women, 38 ; Children, 39.

H. H. JOHNSTON,

Lieut.-Colonel, R.A.M.C., S.M.O., S.S.

FORT CANNING, SINGAPORE,

27th July, 1906.

It has never been determined what is the relative proportion of imported malaria to indigenous malaria, and it is doubtful whether it is worth the while. Immigration is a part of Singapore life which must always go on, and so long as the immigrants come from highly malarious countries they will import malaria, and the only feasible method by which the inhabitants can be protected from this infectious disease is to systematically and regularly remove and abolish the breeding places for malaria-carrying mosquitoes.

Malaria in children.

A suggestion of mine to the Government that an investigation into malaria should be undertaken was very readily agreed to, and Dr. Dane was specially deputed for the work. The scope of the investigation will be gathered from the subjoined form :—

MALARIAL INVESTIGATION.

Number.	Date.	Street.		Name.		Sex.	Age.	Spleen.	Variety Parasites found in blood.	Pigmented Leucocytes.	Leucocytosis.	How long resident Singapore.	Where from.	Mosquitoes.	Larvæ.	Remarks.
		Name.	Number.	Surname.	"Christian."											

So far, 398 children have been examined with the results shown in the following tabulated statement :—

MALARIA IN CHILDREN.

Nationalities.	Total Number Examined.	Total Number Infected.	Percentage of Infected.	Under 2 Years.			2 Years and under 5.			5 Years and under 10.			10 Years and under 20.		
				Number Examined.	Number Infected.	Percentage Infected.	Number Examined.	Number Infected.	Percentage Infected.	Number Examined.	Number Infected.	Percentage Infected.	Number Examined.	Number Infected.	Percentage Infected.
Europeans and Eurasians ...	138	10	7·2	17	—	—	42	5	21%	58	2	3%	21	4	19%
Chinese ...	112	8	7·1	61	4	6%	12	—	—	11	2	18%	29	2	6%
Malays, Indians and others ...	148	14	9·4	41	6	12%	31	3	9%	46	2	4%	30	3	10%
Total ...	398	32	8%	119	10	8%	85	8	9%	115	6	5%	80	9	11%

The object of examining children for the malarial parasite and ascertaining the other details in the form was to localise, as far as possible, the special parts of the town that are at present malarious, in order that the particular breeding places of the malaria-carrying mosquitoes might be first dealt with. Dr. Dane does not seem to have been able to pursue the investigation sufficiently far, either as regards the prevalence of malaria in children, or the breeding grounds of the malaria-carrying anophiles, to secure this end, which should result in a map showing

different parts of the town where indigenous malaria is most prevalent, and the pools and other breeding places in their immediate vicinity where malarial-bearing anophiles have been causing malaria.

It is important also to ascertain what species of anophiles are found. With this information before them, the Health Department could direct their first anti-malarial campaign against these special localities, leaving the others until they had dealt with the worst. Malaria should be included in the list of notifiable infectious diseases.

74. Classification of swamps in Singapore.

The swampy nature of many localities in Singapore has already been mentioned. The swamps come under four classes :—

1. Those at the foot of irregular-shaped hills and their spurs.

2. Those formed on low-lying land in the vicinity of the Singapore, Rochore and Kalang Rivers.

3. Those artificially produced by excavation such as sand pits and clay pits.

4. Those produced on low-lying land by flood water and absence of drainage.

75. Swamps at the foot of hills.

As examples of swamps formed at the foot of hills, those in the neighbourhood of Tanglin Fort may be mentioned. Between the men's barracks, situated on a high ridge, and Holland Road there is a jungle-covered swamp, in close proximity to the barracks, and polluted by slops, ablution water and washings from latrine floors and urinals. In the valley intervening between Tanglin Hill and the officers' mess there is another swamp polluted in a similar fashion, while between Alexandra Road and the south side of the barracks is a third swamp.

In 1905, there were 136 cases of malarial fever and 99 cases of simple continued fever among an average strength of 1,010 European troops.

76. Methods of dealing with them.

These and other marshes of a similar type, of which there are many in Singapore, require a different kind of treatment from that necessary in the three other classes of marsh or swamp. They can be effectually dealt with by methods on the same lines as those adopted at Klang, in the Federated Malay States. There the land is dried by the construction of contour intercepting drains, in addition to the ordinary water-way drains. This system, which is not infrequently used by planters for drying marsh lands, has the double merit of simplicity and of not being costly.

77. Tidal swamps.

Examples of tidal swamps are numerous in the vicinity of the Singapore River. The main branch of this river takes its rise as a small hill stream from the high lands south-west of the Tanglin Barracks, and receives tributaries from Mount Faber ridge on the south side. Its course, as a fresh-water stream, is very short, and its greater portion is tidal. The Singapore River is in its most important part a small tidal creek, sinuous in its course, and not more than a couple of miles

long in a straight line with, where the land is low, a network of inlets branching from it. When the tide rises the sea-water passes up these inlets or channels, overflows on to the low-lying land, and forms extensive mangrove swamps; when it falls, the water recedes and leaves the channels, swamps and a portion of the banks of the river a series of foul-smelling mud flats intensified by the discharge of the drainage into them of houses and pile villages as well as the drainage from Sago and Blachan factories. There is insufficient time for the foul water to reach the mouth of the river and discharge itself into the sea before the tide rises and brings it back to the swamps. The water is thus pounded up, and all of it cannot get out of the reaches between the tides. This absence of sufficient renewal of the tidal water aggravates the nuisance in this locality.

78. Methods of dealing with them.

For effectual removal of the nuisance works are necessary to prevent the tide reaching the swamps, which should then be reclaimed and filled up.

For a little more than a mile from the river this has been done, and the land has been reclaimed on either side, and here and there some reclamation has been effected higher up. Certain important branching water-ways have also been filled up such as the Singapore Canal, in 1883, Powis Creek, in 1902, and Tampines Creek, in 1903.

The most important reclamation now going on is that which is being carried out by the Government and Father Couvrer. The latter, assisted financially to the extent of 9,000 dollars by the Government, has cut a straight canal through the swamps, and sinuosities of one of the branches of the Singapore River, putting half the material excavated on the Government land and half on his own. Father Couvrer is now engaged reclaiming the swamps on the north side of the canal with the material obtained from Mount Zion Hill. It is a magnificent improvement accomplished by a private individual, and if the area thus reclaimed from the swamps is carefully planned out for building purposes and healthy houses and warehouses erected, a healthy and highly useful and remunerative area will replace an unsanitary and useless waste.

The Government are reclaiming the swamp on the south bank of the canal by dredgings from the river, to be covered by red earth from an adjacent hill. The extent is a little over 50 acres, on an approximate estimate of 430,000 dollars, of which 20,000 dollars are being expended in 1906. It is a very important work, but the vigour and progress, so marked on the north side of the canal, are not discernible on the south. The scheme is an excellent one, and the outlay should, ultimately, be recovered by the sale or lease of land for building sites. In connection with these works the Honourable Colonial Engineer has pointed out the great desirability of diverting and shortening the course of the river by a straight cut through the tongue of swamp land below Kim Seng Bridge, and also the straightening of the approach to the canal. The project is one which would materially improve the health of the locality, remove the

nuisances which at present emanate from the marshes concerned, and would at the same time greatly facilitate the traffic on the river and canal.

A policy of gradual reclamation and drainage of the upper reaches of the river and all those creeks and back washes which end in swamps in the neighbourhood of Kim Seng Bridge Road, Havelock Road and Outram Road should be pursued, whether they belong to Government, to private persons, or to the Municipality. The district is not more than a mile from Fort Canning, and it is impossible in its present condition for it to be healthy or free of nuisances. A policy of the kind mentioned would take years for its completion, but if it were realised that the one great need of this locality is reclamation, with drainage, it would conduce to rapid progress. The Government should fill up and drain the several creeks or water-ways having their outlets into the river, as they have already done in the case of those nearer its mouth, and the owners of the swamps and low-lying land should be called on to raise, drain and reclaim their lands. The Municipality should put into force Section 10 of the Nuisance Removal Powers, and should also, on failure of the owners to comply with the notice, be in a position to fill up and drain the land themselves and hold and make use of the land so reclaimed until the cost of filling up and draining has been recovered. There is plenty of good material in the numerous hills close to the swamps.

79. Methods which should not be adopted.

The reclamation should not be on the lines carried out at present by the Municipality. For instance, close to the portion being reclaimed by the Government and Father Couvrer, there is a swamp that is being filled up by the Municipality, not with earth obtained from any of the hills in the neighbourhood, but with the garbage and refuse of the town. The pest of flies and the offensive nuisance arising from this very insanitary mode of disposal of a portion of the town's refuse within Municipal limits are, with reason, strongly complained of by those who have to pass the locality or live anywhere near the neighbourhood. The method ought to be condemned and discontinued. It is a pernicious nuisance, and of an evening the smell is wafted for a half-mile or more from the locality in which the nuisance arises. Apart from the nuisance arising from the operation, it is a very unprofitable method of reclamation, as the land cannot be used for the erection of healthy dwelling houses.

80. Excellent suggestion of the Municipal Engineer.

The Municipal Engineer, Mr. Pierce, makes an excellent suggestion, and one which recommends itself for adoption. It is that some 50 acres of marsh land should be acquired by the Municipality, that an incinerator should be placed near this, and that the clinker and ashes from the furnaces, obtained by burning the refuse and garbage of the town, should be used as material for filling up the marsh. Several such swamps could be selected, and more than one incinerator employed. The incinerators I would recommend are Horsfall's.

81. Swamps at Pulau Brani and their treatment.

Clinker and ashes are being used at Pulau Brani for reclamation on a large scale by the Straits Trading Company, who have their smelting works there. Pulau Brani, now the headquarters of the Engineers, is an

island which used to have a swamp that almost divided it in two. A large portion of this has been filled up by the Straits Trading Company, but the rest still remains with other swamps.

That the remaining swamps are unhealthy will be gathered from the following statistics, in one case covering seven months of 1906, and in the other only three months. The statistics were supplied by Lt.-Col. Johnston, R.A.M.C., the Senior Medical Officer of the Straits Settlements. The type of malaria at Pulau Brani is generally severe :—

RETURN OF CASES OF MALARIAL FEVER AMONG THE TROOPS AND THEIR FAMILIES AT PULAU BRANI, SINGAPORE, STRAITS SETTLEMENTS, DURING THE SEVEN MONTHS JANUARY TO JULY, 1906.

EUROPEAN TROOPS.

Cases.	Pulau Brani.	
	Average Strength.	Cases of Malarial Fever.
Officers	8	2
Warrant Officers, Non-Commissioned Officers and Men ...	118	40*
Women	15	6
Children	26	11
Total	167	59

* Includes patients admitted into hospital and men treated in barracks.

ASIATIC TROOPS (MALAYS).

Cases.	Pulau Brani.	
	Average Strength.	Cases of Malarial Fever.
Officers	—	—
Warrant Officers, Non-Commissioned Officers and Men ...	44	12*
Women	29	—
Children	30	—
Total	103	12

* Patients admitted into hospital during the three months January to March, 1906. The Singapore (Submarine Mining) Company, Royal Engineers, was disbanded on 1st April, 1906.

On the occasion of a visit which I made to the island with Lt.-Col. Johnston, R.A.M.C., and Colonel Sankey, C.R.E., an agreement was come to with Mr. Archdeacon, the manager of the works, whereby the filling up of these swamps should be effected in a systematic and rapid manner. Mr. Archdeacon very readily agreed to arrange that 30 cubic

yards out of the 50 derived daily from the works should be used for the reclamation of a large swamp at the southern end of the recreation ground at Sinki Bay, and that 20 cubic yards should be used daily for the reclamation of a much smaller, but pestiferous, swamp, near to the Marine Mining Barracks, and on the west side of the works.

Colonel Sankey, C.R.E., was to furnish a plan of the latter swamp, and Lt.-Col. Johnston, R.A.M.C., to mark on it the worst parts nearest the quarters in order that these might be filled up first. The whole of this swamp was to be filled up in six months' time. Colonel Sankey agreed to immediately clear the swamp of mangrove trees and jungle, so that operations might begin at once.

The low-lying and marshy ground at the head of Sago Bay could be easily filled up by the War Department from the adjacent hillocks and high ground, and there can be no doubt that if such reclamations, together with those already mentioned, were regularly and systematically carried out, with proper attention to grading and surface drainage, the island, which at present has an evil reputation for malaria, would lose this pre-eminence. Attention should at the same time be given to the earth drains coming down from the higher ground and quarters. All huts built on the island should also be subjected to building regulations and should be constructed according to a definite plan on regular lines to facilitate drainage and scavenging, and care should be taken that they are kept in a sanitary condition. Owing to the absence and enforcement of such regulations and such plans, many exceedingly insanitary dwellings and localities are to be seen. Special attention is also required that drains once constructed shall be kept in proper order. In connection with this many drains were noticed, at the time of inspection, to be in need of repair and out of level. These defects, and others, have, I understand, been previously reported on in detail by Lt.-Col. Johnston, R.A.M.C.

82. Low-lying land in vicinity of Rochore River unhealthy.

It will be noted from the information in appendix B, page 135, that along the banks of the Rochore River and its neighbourhood, the inhabitants suffer from malaria. The cause is to be assigned to the swamps and puddles formed in the low-lying ground, where building operations have been permitted to proceed without the land being first of all raised and drained. Jalan Nepah, Jalan Tambah, Chitty Road, Weld Road, and Dickson Road, comprise an area which suffers in this way, intensified by the small creek that runs through Klantan Road and joins the Rochore River, bringing up tidal water into this district. The first important measure is to prevent the tidal waters passing up the creek, and the next is before the comparatively few houses in this area become numerous to introduce a scheme whereby the land shall be raised and drained. No house should be permitted to be built in any district without the land being raised to the satisfaction of the Health Officer and Engineer, in order that they may conform to the requirements of any sewerage and drainage schemes that may be devised.

In the reclamation of land, due regard should always be paid to the natural slope and drainage of the locality. Thus, when the material from

a hill is being used for filling up a swamp the land raised should not only be well above the adjoining public road, which is sometimes not the case, but the incline or slope of the ground should be towards the public road in order to facilitate drainage of the area reclaimed. Once this is completed the area should be planned out on those sanitary principles that have already been referred to.

83. Treatment of ditches along railway embankment.

The ditches and drains in the vicinity, and on either side of the railway, between Fort Canning and Tank Road, are not kept in proper condition and, consequently, they are breeding places for mosquitoes. In fact, along the railway, Tanjong Pagar to Kranji, there are within the city limits numerous extensive undrained pools, which form breeding places for anophiles. There would be no difficulty in rendering these pools harmless by converting them into storm-water drains.

84. Action should be taken in regard to sand pits, pools, etc.

The numerous sand pits which are being dug out within Municipal limits, sometimes to the extent of several acres, also the extensive clay pits, add enormously to the difficulties of drainage, whilst they form great unhealthy areas on account of their being breeding places for mosquitoes. It is important that the formation of these unhealthy excavations should be prevented and that existing ones should be abolished. It has already been stated that there is no law forbidding the digging of wells, or the making of excavations within the town without the permission of the Municipality. Such powers should be obtained, and no person should be permitted to make an excavation without provision at the same time being made for filling it up with suitable material. The excavations should also have some limit if allowed. It would be better if no sand pit or clay pit were permitted to be dug within Municipal limits. All existing sand pits, clay pits and excavations should be filled up by the owner with suitable material and drained to the satisfaction of the Health Officer and Engineer.

The fish ponds and ornamental waters, well stocked with fish, are in a different category from those mentioned. If well kept, with the banks free of reeds, they are not breeding places for mosquito larvæ. The Municipality should take vigorous and systematic action with reference to the large and small areas of marshy grounds within the town limits, as well as the many pools and excavations. There is ample power in the Municipal ordinance for that purpose. Under nuisances to be abated and to be dealt with summarily under Section 204 there is included "any tank, well, pool, watercourse, ditch or *low marshy ground* which is injurious to health or offensive to the neighbourhood." Any of these that contained anophiles, quite apart from other causes, are injurious to health.

WATER SUPPLY.

85. Gathering grounds.

The gathering ground of the present water supply is a very satisfactory one as regards the purity of the water it supplies.

It is not very large in extent, and it is important that full use should be made of the area in order that the maximum quantity of rain that falls shall be available for storage in the reservoir. That can be secured by having the whole of the area forested, which is not by any means the

case at the present time, some of it evidently only recently having been put out of cultivation, and there is no sign yet of planting. The forrestation will not induce a greater rainfall, but it will conserve the water by allowing it to escape from the gathering ground in more steady streams and thus furnishing a continuous supply to the reservoir. It also lessens the amount of suspended mineral matter otherwise brought down in floods.

Deforrestation acts in an opposite manner. The rain runs off the surface rapidly, comes down in floods to the reservoir, which quickly overflows, with the result that a large quantity of the available supply goes to waste.

86. The storage reservoir.

The storage reservoir, which receives the water from the gathering ground. is also well situated and, with reasonable care, with respect to some of the matters referred to later, there is no reason that the water supplied from this reservoir should not be of a very pure quality. The two main feeders from the gathering ground supply it with a pure water. Analysis of the water of No. 1 Main Feeder at a point where it is not subjected to pollutions, owing to temporary and palpable causes, shows it to be a very pure water. Similarly, the analysis of the water from No. 2 Main Feeder, near the Kallang tunnel, though indicating a quality inferior to that in No. 1 Main Feeder does so mainly because it is subject to pollution brought about by the works above, but which will disappear when the tunnel is completed.

Purity of the water from the gathering grounds.

ANALYSIS OF THE WATER IN THE TWO MAIN FEEDERS OF THE STORAGE RESERVOIR.

	Parts per Million.		No. of Colonies. Per c.c.		Reaction with McCouling's Medium.
	Free ammonia.	Albuminoid ammonia.	On agar.	On gelatine.	
No. 1 Main Feeder above Second Bridge	Nil.	Nil.	180	320	Gas and acid in 48 hours with ·05 c.c.
No. 2 Main Feeder from Kallang ...	Nil.	·030	425	800	Gas and acid in 24 hours with ·05 c.c.

87. Analysis of water in storage reservoir.

There is a difference between the quality of these waters in the feeders and that contained in the reservoir, as seen from the subjoined examination of the water near its outlet.

ANALYSIS OF THE RESERVOIR WATER NEAR ITS OUTLET.

Parts per Million.		No. of Colonies. Per c.c.		Reaction with McCouling's Medium.
Free ammonia.	Albuminoid ammonia.	Agar.	Gelatine.	
Nil.	·122	88	120	Slight gas and acid medium ·25 c.c., medium unchanged with ·05 c.c.

There are fewer bacteria, due to sedimentation, but there is more albuminoid ammonia, due to organic pollutions. It will now be necessary to consider the causes of this pollution.

Water plants in reservoirs favour vegetable pollution.

The first inspection of the reservoir showed an overgrowth of water plants. Certain water plants are not objectionable but others are, and among the latter a species of Chara and Utricularia were noticeably abundant. The Chara is a disagreeable smelling plant, grows submerged in the shallow portion of the reservoir, collects a large number of algæ and deteriorates the palatability and appearance of the water; it also adds to the difficulties encountered in filtering waters containing large quantities of algæ. Utricularia has a similar effect on the water and is a much more rapidly growing plant than the Chara.

As soon as the effect of these plants were pointed out to the Engineer, measures were taken to have them removed as much as possible from the reservoir.

On a second visit to the reservoir Mr. Ridley, the Director of the Botanical Gardens, kindly accompanied me and gave me the benefit of his special knowledge in determining the names of the principal plants growing in the water. In addition to the ordinary terrestrial grasses, such as Victoria Grass, growing on the banks and in the shallow water, there were the fresh water submerged plants, such as Enhydrias Augustipetala, Blyxa Malaccaensis, Naias Minor, Utricularia Exolata, with species of Chara and Minute Algæ, unicellular and thread-like, the chief being Schizothrix, which is like Utricularia on a microscopic scale, and is slimy and offensive.

Enhydrias grows rapidly and tends to choke up everything, Blyxa possesses similar properties; it is a coarse grower and collects algæ. Neither, however, smell like Chara. They, however, decay, and by their rapid growth and silting-up properties become a nuisance. The Enhydrias, the Utricularia, the Chara and the Blyxa if allowed to remain untouched, would gradually fill up the reservoir in its shallower parts, and they increase to a very large extent the amount of vegetable contamination of the water, favour the growth of algæ, and add to the difficulties encountered in its filtration.

The clearing away of these water plants and their regular and systematic removal are, accordingly, an important part in the scheme of purification and should not be omitted.

The Limnanthemum Cristatia, which looks like a water lily but really belongs to the Gentian family, is of no importance from the aspect now being considered.

88.

Ponds and marshes in bays and at inlets to reservoir favour vegetable pollution.

There are other contributing sources of vegetable pollution. At the head of the bays and inlets to the reservoir there are often ponds and marshes through which the water passes before reaching the reservoir. The largest of these marshes is the rice marsh, into which the two main

feeders of the gathering ground discharge their water. The marsh is shallow and much of its water is in a semi-stagnant condition, and the velocity of the flow of the two streamlets which enter it is broken by the growth of Oryzoides Leersia, or wild rice and other rushes.

89. Remedies.

This marsh should be deepened and so constructed as to form a part of the reservoir proper, or it should be filled up and the two feeders should have their water conveyed in a conduit direct into the reservoir. The smaller marshes and ponds should be treated in the same way, and channels so made that the tributaries discharge direct. The waters from the several inlets, under proper protection, are of good quality. and every facility should be given to them to discharge direct into the reservoir in order that they may be prevented from deterioration by admixture with marsh water.

90. Other possible sources of pollution and their removal.

While the main sources of pollution of the reservoir water are from vegetable origin, there are other possible sources of an animal nature that demand careful attention. Thus, while the wokmen are engaged on the Kallang Tunnel, there is always a certain amount of risk from the drainage from the house which the foreman occupies and from the huts of the servants and from the aggregation of a number of men on the slope of the hill leading down towards the Kallang inlet, and especially is this the case after rain. It is a temporary danger which should be removed as soon as possible, and when the tunnel is completed no huts nor houses should be permitted on the slope of the hill which inclines towards the reservoir.

A permanent risk is the drainage from the house and servants' quarters near the outlet of the reservoir. The drainage is supposed to be completely diverted, but a careful inspection shows this is not the case at the time of rain. The Chinese grave also, which is located at the edge of the water of the reservoir, should also be removed.

A careful monthly inspection of the reservoir and its surroundings by the Health Officer and Engineer would hasten the removal of the conditions likely to be deleterious to the water, and would at the same time prevent others of a similar nature arising.

91. Algæ and the filters.

The clearance of the water plants from the reservoir, and the keeping of the banks clear of rushes, together with the carrying out of the other suggestions, will materially assist in overcoming the difficulty experienced in working the filters caused by the algæ in the water. This difficulty is one which exists more at certain times than at others, and has hitherto been met, as far as possible, by the adoption of intermittent filtration or frequent rest and aeration of the filters. The usual time allowed for aeration is 24 hours, but, occasionally, as much as 48 is allowed, including the time required for emptying and refilling; each filter is out of work from two to three days when stopped for aeration. If aeration is not carried out the filtered water turns green and gives off a smell like sulphuretted hydrogen, and a stringy weed grows in the filtered water where exposed to the sun, and the bed of the filter rapidly becomes choked.

92. Sulphate of copper and algæ.

With the object of possibly destroying the algæ and water plants bags of sulphate of copper have been suspended to boats, and these have been rowed across the impounding reservoir in different directions. The result was somewhat obscured by the fact that some of the larger fish were killed and albuminoid ammonia appeared in the water, due, in all probability, to some parts of the reservoir getting a larger dosage of the sulphate of copper than other parts. This has happened in other reservoirs, and yet repetition of the process has proved successful in regard to algæ. A more uniform and accurate method of mixing the sulphate of copper with the water is required, and probably the best arrangement for this would be the addition of the sulphate of copper in due proportion by some automatic appliance near the termination of the two feeders to the reservoir.

93. Aeration before filtration.

If after the carrying out of the measures suggested, and after the introduction of a more effective size of fine sand as recommended later, the algæ and vegetable organic matter still give trouble, it will be necessary to adopt, before filtration, the aeration of the water on the system devised by Mr. Osbert Chadwick and now in operation in the Mauritius. The intermittent filtration is costly owing to the frequency with which the filters have to be rested and, consequently, the large percentage of filtration area always out of use. Intermittent filters, as a rule, have not the bacterial efficiency of continuous filters. By dealing with the algæ before filtration it should be possible, with effective sand, to filter $1\frac{1}{2}$ to 2 million gallons of water per acre of filter area per day, instead of 670,000 gallons to 1,040,600 gallons per acre per day as at present.

94. The position of the filters somewhat exceptional.

The filters are not near the storage reservoir but are within the town. Their position is somewhat exceptional. The old filters are situated immediately at the foot of the hill on which Government House is located and only separated on the other side from the English cemetery by a road. In the report for 1894 the Engineer reports that the floor of No. 3 Filter was lifted up owing to pressure from a spring from the hill. A drain between the hill and the filters was constructed to intercept and carry off any drainage from the hill, and this drain seems to have done its work efficiently.

95. The Fluorescent test applied to ascertain if there were any leakages into the tanks containing the filtered water.

The sub-soil water in the cemetery occasionally gets dammed up during high tides, and it was essential to ascertain whether at these periods the obstruction affected the sub-soil water in that part of the cemetery nearest the covered clear water tank close to the filter beds or the storage tank under one of the filters, as both tanks are below the surface level of the cemetery. For this purpose a series of wells were dug in the cemetery. From these it was seen that a deep layer of clay intervened between the road and the cemetery which acts as an impermeable obstruction against the flow of sub-soil water from that part of the cemetery adjacent to the tanks. Large quantities of Fluorescin were put into those wells in which sub-soil water was reached, but with no effect on the water in the tanks or the filter-wells. This test is a delicate one,

PHOTO VIII.

Shows the situation of some of the houses on the hill in relation to the proposed filter beds in the valley.

the green colour produced being detectable even when only one part of Fluorescin is present in one hundred million parts of water.

96. Conclusion. No contamination.

The conclusion arrived at, therefore, notwithstanding the apparently unfavourable position of the tanks, is that the water in them is not subject to contamination from the cemetery.

The Fluorescin test was also applied to ascertain if the drainage from the septic tank belonging to Government House contaminated the drinking water. The result proved that it did not, but there can be no doubt that this drainage effluent should be diverted and not allowed to pass, as it does at present, through a corner of the premises belonging to the filter beds not far from where the washed sand is stored. The septic tank should also be treated weekly with kerosine for it swarms with mosquito larvæ and is a very fertile breeding place for mosquitoes.

97. Filter premises need more protection.

The area below Government Hill allotted to the premises of the filters is a contracted one and is not sufficiently enclosed and protected. The cleanliness and freedom from risk of pollution of these premises are a matter of the first importance and the area should be so enclosed as to prevent access to the public.

98. The new filters in process of construction.

The new filters are being constructed in the valley between Cavenagh Road and Mouks Hill, not far from the old. The area on which they are to be located is not on the large scale to be expected from such important works ; on the contrary, the site is cramped, and there is no large area of unoccupied land surrounding the filters and belonging exclusively to them ; one side of the valley, the Cavenagh Road side, sloping down to the filters, has dwelling-houses upon it, the drainage from which must go down the hill to be intercepted before it reaches the walls of the filters by a small ditch which is to be converted into a drain to carry away the sewage from the houses above.

Photo. VIII. shows the situation of some of the houses on the hill in relation to the filter beds in the valley.

It is far from an ideal arrangement. It is bad enough now when the houses are few and of a better class, but whenever they become numerous, and there is no municipal power at present which can prevent this contingency, the surroundings of the filter-beds will be very much worse.

99. Site should be protected and rendered safe.

Nothing, in my opinion, except acquisition of the five houses on the slope of the hill, will place these filters, as far as this side is concerned, beyond reproach, and in a state of safety, in all weathers and at all times.

On the hill, on the opposite side of the valley, a dwelling-house is on the ridge, but rather more on the filter valley side than on the other. It is possible that the drainage from this can be diverted to the other side of the hill, but it would be better to acquire it.

Even with the houses removed, there should be ample drainage provided on the two sides of the valley.

100. The effect of the filters on turbidity excellent.

The effect of the filters is very marked as regards turbidity. The water on the filters and that in the filter wells present a striking difference, the former being muddy and the latter quite clear.

101. Their chemical and biological effect not so good.

Chemically and bacteriologically the difference is not so great. The water after it passes through the filters is a pure water, but there are indications that the best results are not always obtained.

A comparison of the unfiltered water on the surface of eight filters with the filtered water from the filter wells of each filter is given in Appendix B, series viii.

102. The chemical efficiency of the filters vary much.

The results show that the filters vary in efficiency from a chemical point of view. Nos. 2 and 6, at work two days, removed 100 per cent. both of albuminoid ammonia and free ammonia. No. 12, at work for one day, removed 70 per cent. of albuminoid ammonia and 100 per cent. of free ammonia, while the others longer at work removed the following amounts :—

	Alb. NH_3 per cent.	Free NH_3 per cent.
No. 9 filter at work 3 days removed ...	74	43
,, 8 ,, ,, ,, ,, ,, ,, ...	65	91
,, 3 ,, ,, ,, ,, ,, ,, ...	67	8
,, 11 ,, ,, ,, 4 ,, ,, ...	89	91
,, 7 ,, ,, ,, ,, ,, ,, ...	69	59

103. The biological efficiency also varies.

Great variation occurs in the biological efficiency, as will be seen by the following table :—

	Pecentage of Bacteria.
No. 12 filter at work 1 day removed	54
,, 2 ,, ,, ,, 2 days ,, ...	63
,, 6 ,, ,, ,, ,, ,, ,, ...	37
,, 3 ,, ,, ,, 3 ,, ,, ...	4
,, 8 ,, ,, ,, ,, ,, ,, ...	39
,, 9 ,, ,, ,, ,, ,, ,, ...	43
,, 7 ,, ,, ,, 4 ,, ,, ...	50
,, 11 ,, ,, ,, ,, ,, ,, ...	40

As the biological standard of efficiency of sand filters is the removal of at least 98 per cent. of the bacteria, it will be seen that the filters at the Singapore works from this point of view are below the standard of efficiency, although some allowance may be made for the Singapore water being one which contains at the most few bacteria.

104. Causes of inefficiency.

To explain the lack of efficiency it will be necessary to consider the composition of the filters. The material used for the filters consists of fine sand from Gelang and coarse sand from the reservoir and Serangoong. Sea sand was tried but it appears to have failed. It is stated to have

PLAN XXIV

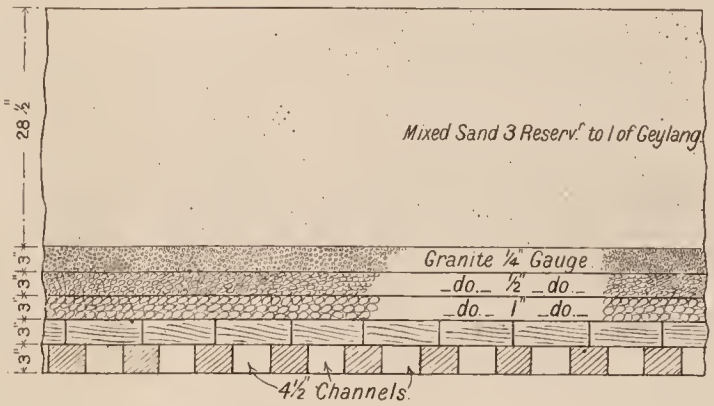
WATER WORKS _ FILTER BEDS.

SCALE, ½ INCH TO 1 FOOT.

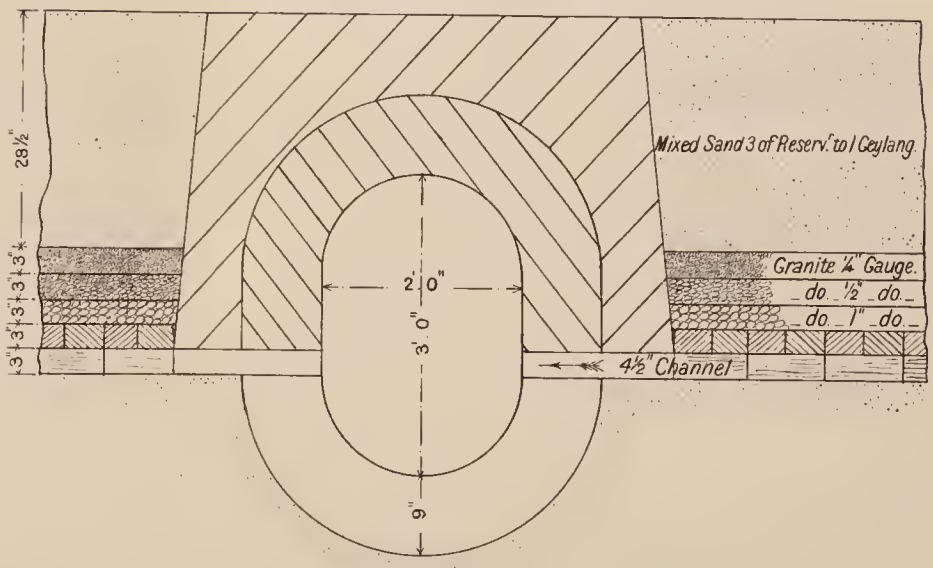
FILTER Nº 1.

At date of Examination there was a deposit of Mud 1/16 thick on the floor.

LONGITUDINAL SECTION.



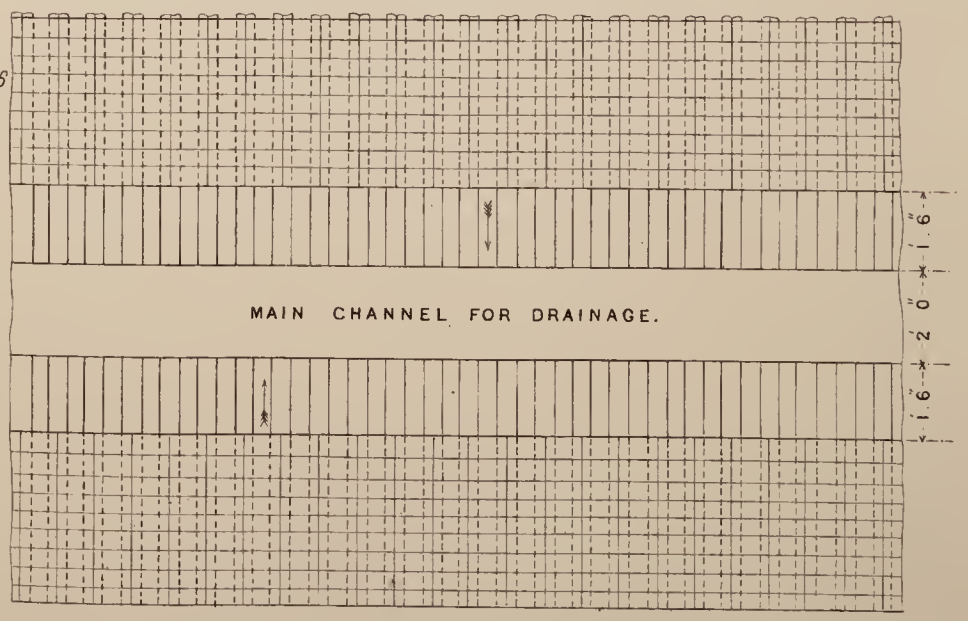
TRANSVERSE SECTION.



PLAN ON TOP OF BRICKWORK

FOR SECTIONS OF FILTER Nos 1, 2, 3 AND 4.

SCALE ¼ INCH TO 1 FOOT.



NOTE:—

The Depths of sand shewn were measured in August, 1906 During working the depth of sand varies from 12 to 37 inches depending on the number of times scraped.

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been found unsuitable owing to decomposition of shell fish, was very difficult to clean, and imparted a brackishness to the water.

Formerly the filters were made up of two layers of sand laid on three layers of screened granite of different sizes. Of the two layers of sand the lower was coarse reservoir sand and formed 50 to 75 per cent. of the total thickness; the upper was fine Gaylang sand and formed 25 to 50 per cent. of the total thickness.

Formerly the proportionate thickness of the layers of fine to coarse sand not adapted to secure the best results.

The proportions of 75 per cent. of coarse and 25 per cent. of fine—as regards the thickness of their layers—are just the reverse of that which obtains in a good filter. The efficiency of a filter depends on its fine particles of sand and on the thickness of its layers of fine sand, the coarse sand acting chiefly as a support to the layer of fine sand. The thicker the coarse sand layer is the more it displaces the filtering medium and affects its efficiency.

At the present time the sand is mixed in the proportion of three parts of coarse reservoir sand to one part of fine Gaylang sand, and is 24 ins. thick in the new filters and 37 ins. in the old. Plan XXIV. shows the sections of one of the filter beds.

There is no special scientific method adopted for mixing the coarse with the fine sand, and the want of uniformity of the mixture, which may arise in consequence, is a serious obstacle to efficient filtration. But even with the best mode of mixing the results are not likely to be satisfactory, because of the size of the sand grains. A simple inspection is enough to satisfy one that the size of the particles of coarse sand is too large and varying for a good filter.

The following table gives the mechanical analyses of the Gelang fine sand and the reservoir and Serangoong coarse sands, also the sands as mixed and the sand as it is in some of the filters :—

MECHANICAL ANALYSIS.

Number.	Sand used in Filter Beds.	1 More than 4·2 m.m. diam.	2 Between 4·2 and 2 m.m. diam.	3 Between 2 and 1 m.m. diam.	4· Less than 1 m.m. diam.	Total Weight.	1 % More than 4·2 m m. diam.	2 % Between 4 and 2 and 2 m.m. diam.	3 % Between 2 and 1 m.m. diam.	4 % Less than 1 m.m. diam.
4	Washed heap, 2 coarse, 1 fine	7·65	32·55	71·6	94·1	205·90	3·71	15·80	34·77	45·70
10	Filter No. 8—1st 6 ins. from top	3·2	56·0	87·4	73·42	220·02	1·45	25·45	39·72	33·36
7	„ „ 2nd „ „	3·3	58·7	89·0	81·9	232·9	1·41	25·20	38·21	35·16
9	„ „ 3rd „ „	3·2	62·8	90·8	71·5	228·3	1·40	27 55	39·77	31·31
2	Reservoir sand, unwashed, from heap ...	5·3	49·0	80·0	77·2	211·5	2·50	23·16	37·82	36·50
1	Fine Gaylang sand, unwashed, top of heap ...	1·4	13·0	45·4	172·4	232·2	·60	5·60	19·55	74·24
3	Perangoon coarse, unwashed, below heap ...	5·8	65·0	125·6	87·9	284·3	2·04	22·86	44·17	30·92
8	Filter 8, Side 1st, 6 ins. from top	2·2	52·0	96·0	84·0	234·2	·94	22·20	40·99	35·86
6	„ , „ 2nd, „ „	3·6	54·6	94·2	88·9	241·3	1·49	22·62	39·03	36·84
5	„ , „ 3rd, „ „	3·7	52·7	88·7	70·5	215·6	1·71	24·44	41·14	32·69
C	Scraping from surface, Filter No. 5	2·9	29·8	39·0	11·8	83·5	3·47	35·69	46·71	14·13
D	„ „ „ , „ „ 11	3·8	61·0	62·6	36·8	164·2	2·31	37·14	38·12	22·41
E	New white sand, washed	4·8	24·6	61·5	87·2	178·1	2·69	13·81	34·53	48·96
F	„ „ „ , unwashed	·8	18·9	49·8	154·7	224·2	0·36	8·43	22·21	69·00
I	(1) New sand as mixed on top of Filter No. 4	11·9	79·9	166·5	194·0	452·3	2·63	17·66	36·81	42·89
J	(2) Coarse sand, Filter No. 4, old	13·2	108·2	159·5	123·9	404·8	3·26	26·73	39·40	30·61

106. Great variety in the size of the sand particles, with existing arrangements.

The percentage of particles passing through meshes of different sizes point to a variety of sizes and largeness of dimensions unusual in filters.

Want of approximate uniformity in size of particles leads not infrequently to distinct fissures or tracts in filters, and thus to loss of efficiency, for unfiltered water passes more rapidly through these tracts and is subjected to less purification than in other parts of the filter.

These conditions, coupled with the unsatisfactory mixing, will account for the present short life of the filters in respect to efficiency.

107. Sand on filters too coarse.

The result of the mechanical analysis is sufficient to show that the sand employed on the filters is far too coarse for biological purification. It will be seen that with only a few exceptions the grains of sand whose dimensions are finer than a *millimetre* only amounts to a little over 33 per cent., and in some cases to less, whereas in most biological filters the percentage is from 66 to 80 per cent., and the effective size of the sand grains is seldom over ·4 millimetre, and generally less.

As the sieves used by the Government Analyst in Singapore were not sufficiently fine, I had some of the samples of sand subjected to a further analysis in London. Mr. H. F. Rutter, one of the Chief Engineers to the Metropolitan Water Board, kindly undertook this for me, and his report, appendix B, pages 135B and 135C, confirms the conclusion already formed as to the unsatisfactory condition of the sands. As regards the size of their particles for filtration purposes, he says: "The results are quite sufficient to condemn practically all the samples except that one marked Fine Gayland Sand (48). This is the one which approximates most nearly in its composition from that which we obtain good results in practice."

118. Filters require more frequent cleansing.

Another contributing factor to the short life of the filter is probably the long interval allowed to elapse between the taking up and cleansing the whole filter. The Engineer has had much difficulty with the cleaning of the filters on account of their fewness, and he has, naturally, not felt justified in putting one or more out of action so long as is necessary for a thorough cleansing. An examination of the channels underneath one of the filters showed it to be dirty, and an analysis of the mud found in them gave 490 parts per million of albuminoid ammonia.

The filters probably require to be put out of action and cleansed from top to bottom at least once in two years, the granite and sand being taken up and the channels flushed out.

119. The quality of the water in the filter wells does not represent the quality delivered.

The analyses of the water from the filter wells does not represent the quality of the water in the high-level reservoirs ready to be delivered to the stand pipes and the houses, for, owing to there not being a sufficient number of filters to filter the whole water, only 75 per cent., and sometimes a good deal less, is filtered. As will be seen in appendix C, page 155, the average percentage of water filtered for the year 1904 was 48 per cent., for 1905 60 per cent., and for nine months of 1906 52 per cent. The filtered and unfiltered water are mixed in the clear water tank or low reservoir and the mixture pumped into the mains. The practice is not commendable, but, under the circumstances, seems to have been unavoidable. It, however, undoes the protection afforded by the filters and converts them into filters against turbidity, and this only in a relative degree, for notwithstanding the cost of filtration in this partial manner, nearly everyone in Singapore, before he can drink the water delivered, has to filter it, entailing thereby, on the householder and others, considerable expense.

110. Partial filtration no protection.

If the water supply accidentally became polluted at its source or at the impounding reservoir there would be a widespread epidemic among those who drink this water, for the partial filtration of the water, and then its mixture with unfiltered water, would not secure safety. The importance of every possible safeguard being placed on the source and at the impounding reservoir will, under the circumstances stated, be now thoroughly understood.

111. Economic side of the question.

There is an economic side also to this question. Examination of the water contained in the clear-water tank, the low-level reservoir and the high-level reservoir demonstrated that the waters in the clear-water tank and low-level reservoirs were very little superior, either chemically or bacteriologically, to the unfiltered water contained in the reservoir or to that coming from the reservoir main on the surface of one of the filters, and that the water in the high-level reservoirs was worse. This is seen in the subjoined analysis. A fuller analysis is given in appendix B.

CHEMICAL ANALYSIS.—BACTERIOLOGICAL EXAMINATION.

	Parts per Million.		Number of Colonies.		Reaction in McConkey's Medium.
	Free NH_3	Alb. NH_3	On Agar.	On Gelatine.	
1. Reservoir near Outlet Tower	Nil.	·122	88	120	Slight acid and gas in 48 hours with ·25 c.c.
2. Unfiltered Water on No. 6 Filter ...	·070	·116	120	180	Gas and acid in 24 hours with 1 c.c.
3. Clear Water Tank ...	·046	·096	85	120	Gas and acid in 24 hours with 1 c.c.
4. Low-level Reservoir...	·050	·106	70	85	Gas and acid in 24 hours with 1 c.c.
5. High-level Reservoir, Mount Emily ...	·046	·130	75	110	Gas and acid in 24 hours with 1 c.c.
6. High-level Reservoir, Pearl Hill	·070	·130	Not taken	Not taken	

From the figures it will be seen that the net result, after all the expenditure on filtration, is that the water delivered from the high-level reservoirs is not any better in quality than that obtainable direct from the reservoir without filtration. The quality of the water in the impounding reservoir varies, as has been ascertained by a daily analysis of the unfiltered water for a period of six months.

112. Is there, in addition to the impurity caused by mixture, any extraneous contamination?

In consequence of the mixing of the filtered with the unfiltered water in varying proportions, and the admixture taking place sometimes in the clear-water tank and sometimes in the low-level reservoir, it was difficult with such conditions continuing to ascertain how much of this impurity was due to the mixture or to any extraneous contamination, if any.

Since, however, the unfiltered water, coming direct from the impounding reservoir, was as good in quality as the water in the high-level reservoirs, it was decided to cut off the filters for some days, and run the water direct from the reservoir into the clear-water tank, low-level reservoir

and high level reservoirs, in order that an analysis of these waters might determine if there were any extraneous contamination besides that of the admixture of the filtered and unfiltered water.

The analysis of the unfiltered water is as follows :—

CHEMICAL ANALYSIS.—BACTERIOLOGICAL EXAMINATION.

	Parts per Million.		Number of Colonies.		Reaction with McConkey's medium.
	Free NH_3.	Alb. NH_3.	On Agar.	On Gelatine.	
1. Impounding Reservoir ...	·076	·122	75	88	·05 no change in 48 hours. Gas and acid in 48 hours with 5 c.c.
2. Entrance to No. 2 Filter Bed	·052	·124	92	110	Ditto.
3. Clear Water Tank—					
Inlet	·046	·120	80	96	Ditto.
Outlet	·042	·110	84	104	Ditto.
4. Lower Level Reservoir ...	·056	·132	94	125	·05 c.c. gas and acid in 24 hours.
5. Pump Well	·036	·116	76	92	·05 no change in 48 hours. ·25 c.c. gas and acid in 24 hours.
6. Mount Emily Reservoir...	·050	·146	90	110	Ditto.
7. Pearl's Hill Reservoir ...	·042	·120	70	80	Ditto.

113. Lower level reservoir requires protection.

The low-level reservoir gives an inferior analysis to that of the clear water well. Its surroundings are not very satisfactory. It is desirable that an improvement should be made in these both as regards cleanliness and drainage. All surface drainage should be so diverted as not to come near this reservoir.

114. Mount Emily reservoir requires protection.

The water in Mount Emily reservoir has also a distinct increase in organic matter, which is evidently attributable to its surroundings. The reservoir is not safeguarded in the manner that an open reservoir containing drinking water should be. The band plays here on certain nights and afternoons, and its banks are a resort for the children and others in the neighbourhood. The remedy lies in putting up railing on the banks where they slope away from the reservoir, and not permitting any but officials responsible for the works into the premises.

115. Systematic inspection of water pipes much needed.

Analysis of the water as delivered in different parts of the town to determine whether there were any local contamination of the supply in its distribution afforded evidence of household contamination rather than district contamination. It was very noticeable that many pipes, when brought into the house premises, were laid on the ground in places which

afforded the greatest risk of contamination if anything happened to be defective in the pipes.

Again, it was also noticed that when the water was cut off from a house the pipe was generally disconnected immediately over the street surface drain, which has already been shown to contain sewage. These two points should be carefully borne in mind in laying pipes so that they may be avoided. Pipes that are brought into private premises should be carried along the interior walls at least a foot above the floors. There should also be a careful inspection of the water pipes in houses and elsewhere as to their position and liability to insuction, owing to leakage and intermittent supply of water. Some of the pipes supplying water to the Public latrines should be laid in a better and safer position.

116. The water supply from Kallang and Seletar.

The arrangements for the water supply from Kallang and Seletar are excellently conceived and designed, and when carried out should give not only the estimated supply but one which is well filtered. In connection with them I have nothing to recommend further than that the impounding reservoirs should be thoroughly cleared of vegetation before the water is admitted into them. While inspecting the sites the Engineer pointed out to me some very effective clearings which had been made of thick jungle by tenants for the purpose of planting pine apples. Similar, and as thorough, clearings should be made of the proposed impounding reservoirs, in order that the difficulties now encountered in filtering the present supply may, as much as possible, be avoided.

On the other hand, care should be taken that the gathering grounds are kept intact, and no clearings permitted in them.

117. Blocking up of older pipes.

Of the older water pipes some taken up were completely blocked, and others in different stages of blocking up. The Engineer is fully aware of this, and is endeavouring, as much as possible, to get the older pipes renewed.

MILK SUPPLY.

118 Practically no tuberculosis among the cattle in Singapore.

There is one good point about the milk supply in Singapore, and this is that it is derived from healthy animals. Although tuberculosis is one of the scourges of the inhabitants of Singapore, tuberculosis among milch cows and buffaloes is a rarity. The Government Veterinary Surgeon informs me that it is practically non-existent. These animals are so housed in open sheds that they live in the open air only sheltered by the roof. There is nothing to object to in either the lighting or ventilation of the cattle sheds. This is in striking contrast to the housing conditions of the inhabitants who, as has been shown, live in badly ventilated and badly lighted houses, and suffer accordingly.

A bad milk supply nevertheless.

This is, however, all that can be said in favour of the milk supply of Singapore, while on the other hand it may be stated that with very few exceptions the conditions under which the milk is supplied to the public

is extremely bad, and is a source of danger to adults and children who may consume the milk unboiled.

The following notes, taken at the time of inspection, represent the conditions in the dairies.

A. Dairy.—Water supply.—Well about 14 ft. deep, 3 ft. from surface, water dark brown in colour, wooden planks round its mouth, but these do not protect it from the surface drainage which flows into it. Water is raised by buckets brought by the coolies and put down anywhere on ground. Coolies bathe at side of well.

Animal Sheds.—Open and well apart, the yard between the several sheds paved with concrete and cement. Sheds drained and paved, but drain's mouth blocked up and the adjacent ground saturated with filth. In one shed a dead buffalo calf in a decomposing state in the manger.

Teats of buffaloes covered with faecal matter.
Most of the sheds overcrowded.
Manure pit close to sheds and a mass of filth.

Milk Shed.—None for keeping milk or milk utensils; no special place for cleansing vessels. Milk utensils generally kept in coolie's living and cook rooms.

In *one room* milk covers and milk measures on the bed with filthy coat. *Milk pail* underneath the bed, which is filthy.

In *another room*, underneath bed, five milk bottles, lid of milk can, collection of rubbish, greasy bags, old rags and boots; part of the room used for stalling calves.

B. Dairy.—Water Supply—An unprotected well receiving drainage from dung heap close to well.

Animal Sheds.—Paved and drained; cesspool full and overflowing; surface drain contains human faecal matter; surroundings covered with dung; indescribably filthy. Shed overcrowded—adapted for 25 animals, contains 53.

Milk Shed.—No special shed for keeping milk. Any milk not sold is boiled and kept in bedroom and then mixed with fresh milk.

Milk Cans and Milk Bottles.—Kept in living rooms, usually under the bed; floors of these rooms dirty. Milk cans and bottles mixed up with soiled loin cloths. No latrine.

C. Dairy.—Water Supply.—Well not protected, receives drainage from surroundings.

Animal Sheds.—Paved and drained; 37 buffaloes, 9 calves, and 3 cows; accommodation for 20 animals.

Milk Shed.—None for keeping milk.

Milk utensils.—Milk pails, milk bottles, milk measure alongside of bed. Some milk pails full of ants, and covered with dirty loin cloths and clothes.

D. Dairy.—Water Supply.—No. 1 well in garden protected only by planks.

No. 2 well receives drainage from shed and surroundings.

No. 3 well receives drainage from yard, which is a morass of filth.

Municipal water brought in a $\frac{1}{2}$-inch pipe through a meter, which is broken.

Sheds.—Paved and drained, contain 320 buffaloes and 70 cows; yards not drained and not paved.

Milk Shed.—None for keeping milk.

Milk Utensils.—Milk pails used indiscriminately for different purposes, sometimes for carrying food for cattle, sometimes for water from wells; kept in Coolie's rooms, usually under the bed.

E. Dairy.—Water Supply.—300 ft. away from animal shed an open unprotected well, within 10 ft. of dwelling hut; another, but nearer well fed from a ditch and a little below the manure heap; a latrine about 6 ft. from ditch.

Animal Shed.—Contains 10 cows, milk pails being washed with mud and sand from floor of cowshed.

Milk Shed.—None.

Milk Utensils.—Kept anywhere in animal shed.

F. Dairy.—Water Supply.—

1. Municipal water, $\frac{1}{2}$-in. pipe.
2. Large well in centre of yard, protected by coping stone from surface drainage; milk pails and buckets dipped into it. Water used at least for washing milk pails.
3. A second well also protected.

Animal Sheds.—Paved and drained and kept in good condition, yard also well paved and drained.

Milk Shed.—No special shed for keeping milk.

Milk Utensils.—No special place for keeping milk utensils and no special arrangements for cleansing them.

In my inspection of the dairies of Singapore I only saw three that were passable, and that could have been made safe, as places from which clean milk could be obtained. One of these was Dairy F.

The milk trade is conducted on two lines, one in which the dairyman supplies milk direct to customers, the cans and bottles for which are kept and washed in the dairy ; the other in which the dairyman sells the milk by the quart to milk sellers, who then carry it round to the houses and retail it either per bottle or per pint. In the latter case, which represents the bulk of the milk trade, the bottle, and cans are brought to the dairy by the milk sellers and kept and cleaned by them at home. The bottles are carried in any dirty old cloth or inside the milk cans, and bathed in the milk.

119. Lines on which the milk trade is conducted.

The homes of the milk sellers are usually dark and ill-constructed sheds, and it is in these, mixed up with the domestic utensils, dirty clothes and refuse, that the milk utensils are kept, the favourite place for the cans, bottles, measures and lids being underneath the bed.

120. Condition of the houses of the milk sellers.

At the time of my visit to the milk-sellers' quarters in Kerban Road, I saw cans and bottles being washed on the roadway, the cleansing material used being the mud from the road close to a refuse heap.

From the details given it will be seen that before a safe milk supply is obtainable reforms affecting both the dairyman and the milk seller are necessary. These reforms have been one of the most difficult tasks which the Health Department has had to undertake. Small fines, even continuous ones, are inadequate to bring about the necessary reforms. Buffalo and cow-keepers find it usually more remunerative to pay the fines than to set about putting their dairies in proper sanitary condition.

121. Conclusion.

A number of the dairies or buffalo and cowsheds are erected on low-lying ground quite unsuited for such and impossible to drain in a proper manner. The Municipality should have power to abolish them, and power to prevent keeping of milch cattle in particular areas for supplying milk for sale. In Calcutta the Corporation has power to declare—

122. Suggested remedies.

(*a*) That in any area specified in the notice no person shall keep milch cattle for the purpose of supplying milk for sale ; and

(*b*) That all milch cattle kept in such area must be removed from such area within a period, not being less than three weeks nor more than six months, to be specified in such notice.

Moreover, all notices requiring any cattle-shed, cowhouse or buffalo-shed to be altered, paved, repaired or kept in such a state as to admit of its being sufficiently cleaned or to be supplied with water, or to be connected with a sewer, or to be demolished, are to be addressed to the owner of the building or land to which the cattle-shed, cowhouse, or buffalo shed belongs, or for the use of the occupants of which the same was constructed or is continued. The expense of any such work has to be borne by the owner.

The same powers should be given to the Municipality of Singapore with also power to direct discontinuance of the use of building as a cattle-shed, cowshed or buffalo-shed.

The keeping of milch cows or buffaloes without a license should be prohibited, and anyone contravening the sanitary conditions endorsed on the license should be liable, as in Hongkong, to a heavy fine, and, in the discretion of the Magistrate, to forfeiture of all or any of the animals in respect of the keeping of which he has so offended. The license should be an annual one, and the premises should only be registered after the license has been granted.

No license or registration should be granted unless the premises are to the satisfaction of the Health Officer in respect to water supply, paving, drainage, special accommodation for cleansing and keeping milk utensils and other sanitary conditions.

As regards milk sellers, no person should be allowed to carry on the business without having his premises licensed and registered, and these should be neither licensed nor registered unless there is separate accommodation, apart from the dwelling-house, for washing, cleansing and keeping the milk utensils.

Possibly the most satisfactory method of dealing with this question would be to allow the private company, which, I am informed, is willing to erect a model dairy under the supervision and inspection of the Principal Civil Medical Officer for the Colony, the Health Officer and the Veterinary Surgeon, to undertake the work with the assurance that if it continues the business to the satisfaction of these officers, the hospitals and other Government institutions would take their milk from it. By such an arrangement, a standard dairy could be established and the other dairies in the town which are not abolished could be gradually brought up to a similar standard.

RICE SUPPLY.

123. The importance of preserving rice in a good condition.

The rice supply and the condition of the rice are important matters not to be omitted in a report on the conditions affecting the health of the Singapore community.

It is not necessary to deal with the question as to whether beri-beri and its allied affections are caused and spread by a particular kind of mould of rice or by other unknown agencies. This is a subject which must be settled by careful and prolonged experimental research. There appears to be much evidence in support of the view that rice of an inferior quality plays a part in the prevalence of these diseases, but what rank this part holds is not precisely known. Some credit it with a rank of the first importance, and believe it to be the main cause, the agent being in or developing in the rice. Others assign to it an inferior position, of merely paving the way. Without committing oneself on a matter which is not yet settled, it is sufficient for sanitary purposes to state that there can be no doubt that mouldy and damaged rice is injurious to the health of those who eat it, and, accordingly, every effort should be made to lessen its sale, while at the same time measures should be taken, as far as possible, to prevent it becoming mouldy and damaged. Moreover the rapid deterioration which rice undergoes in the mills, warehouses, stores and godowns of Singapore is a serious loss to the merchant. I was

informed that sometimes the value of the produce was damaged to the extent of 50 per cent. or more. At present it is impossible to store rice for long in Singapore. Reasons will suggest themselves why it is important that this condition of affairs should be altered and an effort made to render it possible to store rice in Singapore for long periods without the risk of it being damaged.

124. Causes of deterioration of rice.

The causes of the deterioration are mainly the fungi of mildew and the larvæ of insects, more particularly the weevil, some damage being also done by the vermin, with which the storehouses are infested.

The climate favours the production of moulds as well as the development of insects, but it is materially aided by the bad conditions existing in most of the storehouses and shophouses. These conditions are heat from absence of ventilation, dampness from improper drainage, darkness from structural defects, and insufficient window space.

125. Protection can be given by disinfecting the rice and godowns.

The storehouses and warehouses can be sanitarily improved, but it is doubtful whether this measure by itself would be sufficient to effect the object in view, viz., the protection of the rice from the attacks of insects and moulds, for once storehouses and warehouses are effected by these in such a climate as Singapore it is impossible except by disinfection to prevent or stay their ravages.

The method of disinfection must be one which, while destroying the moulds, larvæ and insects, will not affect the rice injuriously in any way. This can be done by fumigating the rice in the closed warehouses, storehouses, or shophouse, with a 2 per cent of SO_2 gas, keeping the percentage steady at this point throughout for about an hour, and allowing the gas to remain in the godown for four or five hours, by which time the percentage of SO_2 will have been reduced to less than $\frac{1}{2}$ per cent. by absorption. An "A" type of Clayton's machine would be sufficient for the purpose.

A large Clayton machine is used at Singapore for the disinfection of emigrant ships which have been infected with plague or cholera. The same strength of gas and size of machine are, however, not needed for the destruction of fungi and insects with their larvæ and eggs which infest rice godowns. A small portable machine used for the purpose of disinfecting every two months the stores and shophouses containing rice would probably be found to reduce enormously the loss now incurred, while at the same time it would permit of the rice being stored with safety for a longer period. The same treatment is effective for the preservation of maize, but it is not suitable for the preservation of wheat, fruit, vegetables and fresh meat.

TRADE NUISANCES.

126. The Blachan Factory Nuisance.

The Blachan factories in the Havelock Road district are an offensive nuisance to the neighbourhood and to the passers by. Blachan consists of prawns and shrimps salted and mixed with a maroon-coloured dye. It is brought in Kajang, or cocoanut leaf, bags from Malacca, Deli, Klang, Perak and other places. In Singapore it is sorted. The bags containing the well preserved blachan are packed in cases and sent wherever it is wanted. It is used for Sambal, which is eaten uncooked with curry, and

it is also mixed and cooked with curries. The bags containing the blachan that has not been properly preserved, or which has been damaged in transit, or which has decomposed, are emptied, mixed with more salt, and then stored in godowns. There it remains several months until wanted. It is then dried in the sun, has more salt added to it and maroon-coloured dye, and when ready put into fresh cocoanut bags, packed in cases, and sold.

The smell arising from the storing of the decomposed material mixed with salt in the godown is overpoweringly strong and offensive, and that arising from manipulating it and drying it in the sun is such as to be a nuisance at a considerable distance from the works. In the early morning and in the evening the sickening smell is noticeable in houses situated a quarter-of-a-mile away when the wind is blowing from the Blachan quarter. The smell is similar to, but much worse, than that of a hide godown storing decomposed hides, and has a strong emetic effect on any-one unaccustomed to it.

127. Removal recommended.

This nuisance should be removed to a neighbourhood where there are none or very few inhabitants, such as on the Kallang River, and it certainly should not be permitted, as now, in the vicinity of one of the principal public roads of Singapore, and not far from the central portion of the town. The boats taking up and bringing down the blachan scents the atmosphere for some considerable distance on both sides of the river. That part of the proeedure which deals with the salting of actually decomposing blachan should be prohibited. Once anything is decomposed no amount of salt will make it wholesome or destroy the sporing anærobic organisms of decomposition or their toxines. The footstuff in this condition is unfit for human consumption, being injurious and sometimes dangerous to health. It would be well, however, to ascertain by a careful series of experiments at what stage of the operations in the factory decomposition is reached to justify prohibition of that stage. The experiments undertaken would relate to the anærobic organisms found and to feeding animals with decomposed blachan.

128. The nuisances connected with Sago factories.

The sago factories, most of which are situated in the same district as the blachan factories, are also a great public nuisance, owing to the storage of ampas, and the drainage of the refuse and of the effluent water from the washings of the sago on to the tidal mud flats and swamps adjacent to them.

129. The preparation of the Sago.

The sago factories usually consist of several sheds, the floors of which have been paved and drained, and which contain the various appliances for storage and preparation of the sago. The raw material from the Dutch Islands is brought in tonkangs up the Singapore River to the factory. There it is stored in a shed until required, when it goes through a process of preparation. This consists in first putting the sago into large cotton strainers and washing in large vats. The sago passes through the strainers into the water in the tubs. This is continued until the vats are full of the washed sago. The ampas or refuse which is left in the cotton strainers is put into small tubs at the side of the

vats and is then removed direetly to boats or stored to be sold for feeding dueks, pigs and fowls. A piece of cloth is then plaeed round the edge of the vat whieh eontains the first washed sago, and is so plaeed that on the inner side it eovers a portion of the sago and on the outer dips over the side. This soaks up the water from the sago and allows it to flow down the side of the tub to the surface drain below, from whieh it passes to a catch pit, where any sago that has escaped in the water settles, and the overflow liquid flows into the swamp or mud flat elose by. The sago which has settled in this eatch pit is washed again and forms No. 2 quality of pearl and flour sago.

The solid sago, after remaining two days in the first vats, is transferred to larger vats, where it is mixed with water, stirred and thoroughly washed. In this liquid state it is eonveyed into long wooden settling troughs, which have a series of wooden weirs at the end eovered with muslin. The sago settles in the wooden troughs as a white solid mass, the diseoloured water in which it has been washed flowing off over the surface into a terminal vat. It is important that the sago shall not be disturbed in the process of settling in the wooden troughs, otherwise the smooth surface will be broken and the soiled water will spoil and darken the sago. The liquid eollected in the terminal vats is allowed to settle its sago and the supernatant fluid is syphoned off into the drains, from whenee it flows into the cateh pit, the overflow of whieh passes into the swamp. The sago in these terminal tanks and in the eateh-pit is subjeeted to further washing and troughing and produees No. 2 quality.

The solid sago from the first troughs is eonverted into either pearl sago or sago flour, aeeording to the manner in which it is treated. That from the other troughs is dried and sold as No. 2 flour. The residue from the last tank is dried in the sun and sieved and put into bags and exported as a starch for elothes.

130. Preparation of Pearl Sago.

To produce pearl sago a portion is revatted and washed and passed into troughs, where it settles ; when solid, it is taken out of the trough and put in large blocks on to a wooden table, where it is broken up. It is then sifted through a coarse coeoanut sieve. That which passes through is put into a eotton cloth, hung on a wooden cross, and suspended by two ropes to a beam. The effect of moving this baekwards and forwards is to give a round shape to the sago, which is then put on to a finer mesh sieve to separate the dust and those portions of the sago whieh have not been rounded from the more highly prepared. The latter, whieh remains on the sieve, is then transferred to a special sieve, whieh is adroitly worked by a speeially skilled workman, and it is through this sieve that the small pearl sago passes. After forming, to make it hard and dry, the pearl sago is spread out on malaeea tiles over a furnaee, raked over and thoroughly dried, and when ready is eolleeted and stored. It undergoes another sifting before being put into sacks for export to Europe.

131. Preparation of Flour Sago.

Flour sago is prepared by taking the sago from the trough and letting it dry in a shed for a week. If the weather permits the lumps are after the week broken up, taken out to the open and dried on Saigon grass

mats, which are laid on Attap leaves. A strong sun may dry the flour in a day, but in bad weather the drying may take a week. The dried sago is then stored in bulk in sheds, and is only put in bags when ordered.

132. Industry may be carried on without nuisance.

It will be seen that the sago factories are an important industry, and there is no reason why it should not continue in a flourishing condition, if located in a suitable district, and carried on in a cleanly fashion and on sanitary lines.

Of sanitary requisites the first is a pure water supply for washing the sago—it is absolutely essential that the water shall be uncontaminated and come from an uncontaminated source; the second is, that the cloths and sieves employed shall be washed in clean and pure water; the next is, that the refuse which is sold for the feeding of pigs, fowls and ducks, is not stored on the premises but taken away daily; the fourth is, that the place is maintained in a cleanly condition; the fifth is, that the drainage from the overflow of catch pits, terminal vats and tanks and from the premises does not go into a swamp or to a mud flat, but is conveyed to a drain which can be flushed and cleaned and the drainage properly disposed of; for this purpose the factory must be on a suitable site; the sixth is, that the drying of sago is carried out on an impermeable platform and not on layers of attap laid on the mud ground; and last but not least is, that the sanitary arrangements of the workmen's sheds are cleanly and in good condition, and separated from the sago factory sheds.

133. Insanitary condition of the factories.

How far cleanliness and sanitary requisites are departed from will be gathered from the following notes on sago factories and the photographs of some of their premises :—

No. 1.—Large Sago Factory :—

Water Supply.—Open tanks receiving the drainage from an old cemetery.

Disposal of refuse.—Thrown on side of swamp and wetted every time the tide rises.

Site of latrine.—On swamp.

Drainage.—Flows into swamp. Coolies' quarters under the same roof as factory. Seventy-five coolies.

No. 2.—*Water Supply*—A pond.

Disposal of Refuse—On banks of creek.

Drainage—On to mud banks of creek.

No. 3.—*Water Supply*—Pond at back of coolies' shed, contaminated by drainage, factory drains smell of urine.

Disposal of Refuse—Piled up alongside of shed, and consisting also of attap leaves and filth.

Drainage—Into creek.

PHOTO XI.

Shows rubbish, refuse and dirt on premises of a sago factory, and in proximity to the sago store.

PHOTO XII.

Sago factory, showing drainage discharging into tidal creek. At low tide the creek is a mud flat.

PHOTO IX.

A. Tub for washing sago. B. Drain receiving washings. C. Tidal swamp into which drainage discharges.

PHOTO X.

Pond used until recently for washing sago.

The whole place is in a most filthy condition; drainage from huts and latrines either soaks into ground or flows into a mud drain that passes through the sago premises and discharge into creek. Eighty coolies at work.

Photo IX. Shows part of the premises of a sago factory.

(A) Tub for washing sago.

(B) Drain receiving washings.

(C) Tidal swamp into which drainage discharge.

Photo X. Shows part of another sago factory, with one of the coolie sheds and bathing platform; rubbish is to be seen on one side of the shed. The water has a scum on it. This pond water was, until recently, used for washing the sago. The pond from which the water is now taken is not much better.

Photo XI. Another part of the same sago factory shown in Photo X., shows rubbish refuse and dirt in proximity to the sago store. Coolie shed on right. Sago bags seen under shed in centre.

Photo XII. Part of another factory showing drainage into a tidal creek. It is high tide, but at low tide the creek is a mud flat.

134. The nuisance arising from the sago factories has long been a matter for consideration.

The condition of the sago factories and the nuisance they give rise to have been long a subject of complaint. In 1893 the proposal to remove the factories from their present insanitary sites on the tidal creeks of the Singapore River, near Havelock and Outram Roads, came on for discussion at a meeting of the Commissioners dated the 17th September, and by a majority of two the resolution was carried: "That it is not desirable to deal with the sago factories *en bloc*, but that each and all should be dealt with on its own merits, and the parties interested heard before any conclusions be come to, and that the officers of the municipality be instructed to inquire into and report on each sago factory." The President of the Municipality remarks on this as follows: "To any-one conversant with the question this looks like perpetrating a nuisance under the pretext of enquiry. The Municipal officers have been reporting on these factories for many years, and any further reports can only repeat that they are all very foul, and that their position on the river mud flats does not permit of drainage or scavenging, and that to improve them would cost more than to remove them."

135. Factories should be removed to the Kallang river.

Some of the factories have since been removed to the Kallang river, and this is where I should recommend the remainder to be located, and in such a position that the drainage should pass direct into the river.

When removed to the Kallang river, care should be taken that each sago factory is provided with a clean and wholesome water supply, free of contamination. If beyond the Municipal supply, there is no difficulty in securing good water if the ponds and wells that are constructed are properly protected. The district suitable for the sago factories on the

Kallang river are sparsely populated, and no license should be granted unless the tank or well supplying the water has no dwelling house, structure or erection of any kind within 100 yards of it, except it be the conduit and arrangements for conveying the water to the factory.

QUARANTINE AND HOSPITAL ADMINISTRATION.

136. Coolie immigration and protection of Colony and Federated Malay States from epidemic diseases.

With the enormous number of coolies coming into the Straits Settlements and into the Federated Malay States from countries infected with small-pox, plague and cholera, it is important that the medical inspection of the coolies and the quarantine station both at Singapore and Penang shall be in a state of the highest efficiency. This is necessary in order not only to protect the country from the invasion of destructive and costly epidemics, but also to protect the interests of the mercantile community, whose prosperity largely depends on Singapore and Penang having clean bills of health.

The small annual expenditure involved in maintaining an efficient Port Health Service is nothing compared to the losses which are certain to be entailed when, on account of epidemic diseases prevailing, ships pass Singapore and Penang in order to avoid quarantine at other ports. The return of such shipping is apt to be slow.

137. Improvement needed in the Port Health service at Singapore.

Very great credit is due to Dr. McDowell, the Principal Civil Medical Officer, for the improvements already effected in the Singapore quarantine station, and if they are supplemented by the increase of medical staff essential for the carrying out of the Port Health Officer's work the improvements so much required will be complete.

The Port of Singapore will then be in a position to protect Singapore and its hinterland. It is not in that position at present with one Port Health Officer and no adequate medical staff.

138. The medical staff and quarantine arrangements at Penang totally inadequate.

As regards Penang, its quarantine station and the arrangements for medical inspection might have been suitable enough when few coolies came from India to work in Penang, Province Wellesley or the Federated Malay States. This is not so now, for conditions have changed, and batches of coolies, 1,000 and 2,000 strong, are brought to Penang from Southern India. The coolies are apt to bring the diseases of India with them, and if proper and effective preventive measures are not systematically taken the result will be that these diseases will become both epidemic and endemic in those parts of the colony and Malay Peninsula to which the coolies are assigned. There was a sharp outbreak of cholera in Province Wellesley in May, 1906, and when I visited the quarantine station at Penang in August, 1906, the hospital contained cholera patients brought in coolie ships from Negapatam.

The history of the cholera cases at the Penang Quarantine Station is nstructive, as showing that cholera infected coolies get shipped from India to Penang, and the absence of sufficient precautions to prevent this. The

history was obtained by Dr. Lucy, the acting Principal Civil Medical Officer of Penang, and myself at the quarantine station. It may not be absolutely accurate, but it appears to me to be sufficiently near to justify the introduction of reforms both at Negapatam and Penang.

There are apparently two classes of coolies that come from India—the free and the indentured. It is not necessary here to distinguish the one from the other. The s.s. "Teesta" arrived at Negapatam, from Karikal, with 300 coolies on board on Wednesday afternoon, August 1st; on Friday morning, August 3rd, coolies were shipped from Negapatam, and on Friday evening two of the coolies were attacked with cholera—one of whom died on board. The body was brought the same evening on shore, and the patient was taken from the ship to hospital.

On Saturday morning, the 4th of August, the rest of the coolies were put on board, the total it is stated amounting to over 2,000. On Sunday morning, August 5th, an inspection was made by the Port Health Officer, and the ship started a little after 7 o'clock on Monday morning, August 6th.

From this it appears the ship started 60 hours, or two-and-a-half days, after the removal of the two cholera cases which occurred on the evening of the 3rd, which is obviously insufficient, in that at least seven days is prescribed by the Paris Convention as being necessary for Pilgrims, reckoned from the day on which the last case occurred. The period of seven days replaces the ten days which was formerly enforced.

The history of the ship after leaving Negapatam with 2,000 coolies on board appears to be that, on Monday afternoon, 6th August, *i.e.*, on the same day on which it sailed, one case of cholera occurred, and between the 6th and 9th, when the ship arrived in Penang, another case of cholera.

The quarantine station is adapted for the isolation of about 500 coolies. 1,054 were landed from the ship, and among these several cases of cholera occurred. The remainder of the coolies in the ship were sent on to the Singapore quarantine station, where I am informed by Dr. Lucy some 28 deaths and 32 cases occurred up to the 25th of August. No information as to numbers had reached him after that date, but it was understood several more cases had occurred since then. The next ship, the "Tongwa," arriving at Penang on the 23rd August,. had over 2,000 coolies on board. There was a case of cholera on board on the night before arrival, viz., 22nd August, and another was landed on quarantine island on the 23rd. It was impossible to accommodate these 2,000 coolies, so they were sent to the Singapore quarantine station, and two of the coolies died of cholera on the voyage from Penang to Singapore.

A quarantine station which cannot accommodate more than 600 coolies at the most, which possesses a hospital only of one ward, in which cholera, small-pox, plague and dysentery are treated, and which has to

depend on garden coolies from the leper settlement for its menial staff, is clearly in a very unsatisfactory condition, and totally inadequate for the requirements and protection of the colony and Federated Malay States.

140. Recommendations.

The Medical inspection and staff should be placed on a proper footing, and accommodation provided for 2,000 to 2,500 coolies.

The equipment of the quarantine station should be similar to that required by Article 131 of the Paris Convention, 1903, for Pilgrims.

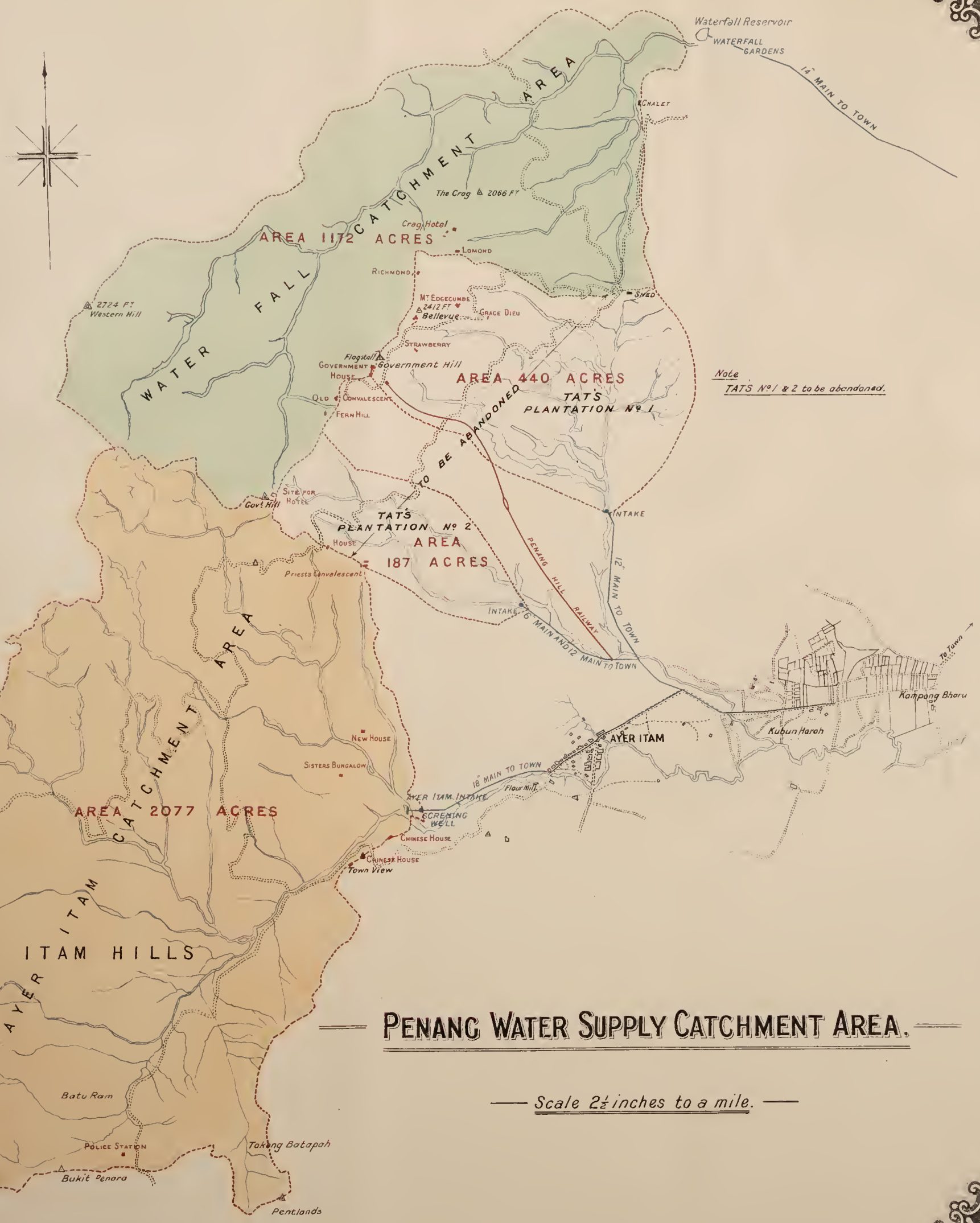
A colonial medical officer should also be stationed at Negapatam to inspect the coolies before shipment, and to ascertain that the precautions required to be taken before their embarkations have been fully complied with.

141. The Medical administration of the Tan Toch Seng Hospital.

I shall not touch on the hospitals of Singapore further than to say that for the successful administration of the large Native Hospital, Tan Toch Seng, with its 18 wards, and average daily number of 560 in-patients, a more complete medical and trained nursing staff is required. The apprentice dressers being untrained when they commence their duties are useless for nursing purposes, and by the time they have learnt something they, as a rule, leave to get better pay elsewhere. I am in accord with Dr. McDowell, the principal Civil Medical Officer, that for this hospital there should be one additional assistant surgeon, nine senior dressers, instead of the junior dressers now employed, and 36 junior dressers, instead of the apprentice dressers, who should be discontinued.

W. J. SIMPSON, M.D., F.R.C.P.

February, 1907.



PENANG WATER SUPPLY CATCHMENT AREA.

Scale 2½ inches to a mile.

WATERLOW & SONS, LIMITED, LONDON WALL, LONDON

FEDERATED MALAY STATES.

1. The towns of the Federated Malay States.

On leaving Singapore on my way to Penang I had an opportunity of visiting Port Swettenheim Seremban, Klang, Kuala Lumpur, Ipoh and Taiping. In these new and small but thriving towns it was obvious that the style of building at Singapore had been adopted more or less for the shophouses and tenement houses, and that Singapore was the model on which the towns shaped themselves. The same principles of light and air necessarily apply to them as to Singapore, and the changes recommended in the building laws in Singapore are as much needed for them.

It is of the highest importance to the future health of these rapidly developing towns that they should be well laid out at the commencement, and that the houses and the streets and the back lanes should be so constructed and arranged that the insanitary conditions which have arisen in Singapore shall be avoided. This can be secured by planning out beforehand each town and its extensions on sound and sanitary principles, and preventing any developments on haphazard lines and which do not fall into the general plan.

PENANG.

Water Supply.

2. Inspection of the gathering grounds.

In Penang, accompanied by Dr. Park, the Health Officer of the Municipality, I made a very careful inspection of the water supply and its gathering grounds. The object of the inspection was not to give an opinion on the means of increasing the supply, but to ascertain the degree of protection from pollution afforded to the present sources.

3. Sub-Committee's recommendation regarding the gathering grounds.

A Sub-Committee of the Municipality recommended in 1903 that all private buildings on the catchment areas be acquired with as little delay as possible, and that the Government be approached with a view to having all Government land on those areas declared as forest reserves and secured against alienation, and it drew attention to the risk of pollution to which the water supply was exposed at its source, owing to the position of two temples, which, at the Taipusum festival, are visited by thousands of Indians, and which it recommended to remove to a situation not fraught with danger to the general water supply. There are, as will be seen on the map, three gathering grounds, one is the Water-fall catchment area, 1,172 acres in extent, another is Nos. 1 and 2 Tats, 627 acres in size, and the third is the Ayer Itam area, with 2,077 acres. The Water-fall and the Ayer Itam catchment areas are the most important, and it has been suggested that for various reasons Nos. 1 and 2 Tats areas might be abandoned.

4. Endorsement of Sub-Committee's recommendations and agreement with medical views.

As a result of the inspection, I fully endorse the views of the Committee on the points they have mentioned, and I agree with the views of Dr. Lucy, the Acting Principal Civil Medical Officer, and of Dr. Park, the able Health Officer, that Tats No. 1 and No. 2 should be abandoned as a catchment area.

5. Reasons for abandonment of Tats Nos. 1 and 2 as a catchment area.

The abandonment would secure several advantages, first, it would allow of Tats Nos. 1 and 2 being further developed for residential purposes, which is a very important consideration; secondly, seeing that so large an area is provided for hill residences, it would render feasible the reservation of the Water fall and Ayer Itam catchment areas; and, thirdly, it would permit of the drainage from the houses already situated on the ridge between the Water-fall catchment area and the Tats being wholly diverted into the Tats instead of as now polluting the sources of the Water-fall area.

By very slight rearrangements agreed to by Dr. Park, this diversion can be made without any serious difficulty in all except, perhaps, the Crags Hotel. The difficulty here arises from the fact that the hotel buildings, unlike the others, are situated on a ridge which juts out from the main watershed forming the catchment area of the water-fall and well into the area itself. The drainage from the hotel passes down the slopes of the ridge and finds its way into the stream. On the north-east slope the night soil of the hotel is thrown into an excavation and, during the heavy rains, is washed down the side of the hill. Next to the mass of night soil is a dumping ground for the refuse of the hotel, and the washings of this are also carried down with the rains. It is clear that such conditions should not be permitted to exist on the catchment area, and yet they may be said to be common to all or nearly all the bungalows on this ridge, including the convalescent hospital. The hill station is a health resort, and is frequented by the sick who seek restoration to health in the delightful climate of the hills, but who are as likely as not to have in their excretions the germs of water-borne diseases.

As regards the diversion of the drainage from Crags Hotel, more difficulty than in the other cases presents itself, but with a good drainage scheme, together with a depôt for excreta and slops connected with the drainage scheme, I think it possible to convey the whole of the sewage of the Crags Hotel into the Tats area, where, with the sewage of the other houses, it might be treated in a septic tank and then by filtration. If the Sanitary Engineer cannot do this then it will be necessary for the Municipality to acquire the hotel.

The Ayer Itam catchment area requires also to be absolutely reserved for the water supply. The huts and houses on it should be removed and the drainage from the Bulat Penara Police Station, which is at the head of one of its streams, should be diverted.

6 Water supply should be filtered.

Apart from the reservation of the catchment areas and their protection from pollution of an animal origin, I am in agreement with the Municipal Engineer and Health Officer that the water from both catchment areas should be filtered in order to clear it from the excessive amount of vegetable matter and silt which it contains and which are well known to cause intestinal disorders. Probably the best mode of procedure would be that recommended by Mr. Bell, the Municipal Engineer, in his report dated September, 1905.

COLLECTION, REMOVAL AND DISPOSAL OF EXCRETA.

7. Methods adopted at Penang.

The arrangements for the removal of excreta in Penang differs in different parts of the Municipality. In the urban parts the Municipality carries out the work by means of its own establishment and removes the excreta to a depôt from whence they are taken in sampans to be disposed of on cocoanut plantations. In the suburban and rural portions the householder is allowed to decide whether the collection and removal shall be done by the Municipality or by a private contractor, who disposes of them on vegetable gardens. If a private person wishes the excreta to be removed by the Municipality an application has to be made to that effect, and the applicants request is granted if the house is not at too great a distance from the depôt.

Some 6,000 latrines are dealt with by the Municipality.

8. Arrangements for collection and removal superior to those of Singapore.

The arrangements for collection and removal are good so far as they go and contrast strongly and most favourably with those of Singapore. The reasons for this are that more latrines are outside the houses and more easily reached in Penang than in Singapore ; that the latrine seat is made to specially fit the pail, so that night soil and urine fall into the pail ; that the soiled pail, with its contents properly covered, is removed and a clean pail substituted; that the vans employed, of which there are 61, each of which holding 30 pails, are well covered ; that the vans make two trips to the depôt, and that all is finished at the latest by 10 a.m., generally by 9 a.m.

The cost of each van is £100, and about 1,000 pails have to be renewed annually.

The vans, each holding 30 empty pails, and accompanied with two coolies, start from the depôt at 5.30 a.m. They return with full pails to the depôt one to one-and-a-half hours after. A staff of coolies, in the proportion of one coolie to each van, removes the full pails and replaces them with empty ones, and the vans again start for their second trip returning an hour to an hour-and-a-half later.

At the depôt the pails are emptied into the sampans, and then thoroughly washed and rinsed with a disinfectant, and set aside to dry. The sampans are taken across the strait to a cocoanut plantation where the excreta are disposed of.

9. Arrangements at depôt primitive.

The arrangements at the depôt and filling of the sampans are of a very primitive nature, and the operations are offensive, but it is proposed to make improvements to remove the nuisance as much as possible. It is thought possible that later a Shone ejector might be used from a more central depôt to convey the sewage to the sampans.

10. The Penang system not recommended for Singapore.

Although the arrangements at the stages of collection and removal are more satisfactory in Penang than in Singapore, I should not recommend Singapore to adopt them. Even in Penang the system can only

be viewed as belonging to a transition stage, and that sooner or later the best system for the urban part of Penang will be a drainage system.

11. Storm-water drains obstructed.

The time at my disposal did not permit me to enter carefully into the condition of the storm-water drainage system. The little I saw appeared to me to indicate that many of the storm water drains were responsible for the flooding and dampness, with its accompanying malaria which affects some of the areas in Penang. The flooding was due directly in many instances to sea water being permitted to flow up the surface drains and overflow on to the low-lying lands and indirectly to the obstruction thus caused to the drainage from the areas beyond on that line of drainage. Evidently there were at one time automatic sluices on at least some of the main outlets to the sea, but for some reason they have been allowed to fall into disuse. A great improvement would be effected if these sluices were renewed, and if the drains outside the immediate centre of the town were cleared, and given proper gradients, and maintained in that condition. The Engineer, I understand, is fully impressed with the importance of the drainage question, and has been engaged for some time past in improving levels, removing obstructions, and substituting concrete and masonry for earth drains.

W. J. SIMPSON, M.D.

February, 1907.

APPENDIX A.

VITAL STATISTICS.

Returns showing the number of Births and the Birth Rate per mille per annum for each Nationality.

1900.

	Males.	Females.	Total.	Birth Rate.
Europeans	55	50	105	11·4
Eurasians	66	55	121	30·6
Chinese	1,096	905	2,001	13·3
Malays	501	487	988	35·5
Indians	164	176	340	17·3
Others	25	26	51	22·7
	1,907	1,699	3,606	17·72

1901.

	Males.	Females.	Total.	Birth Rate.
Europeans	49	49	98	27·41
Eurasians	66	59	125	30·91
Chinese	1,220	1,077	2,297	15·06
Malays	428	448	876	32·11
Indians	182	136	318	18·31
Others	33	28	61	23·01
	1,978	1,797	3,775	18·19

1902.

	Males.	Females.	Total.	Birth Rate
Europeans	32	32	64	17·72
Eurasians	56	54	110	24·34
Chinese	1,371	1,219	2,590	16·49
Malays	441	480	921	33·58
Indians	185	171	356	20·25
Others	32	25	57	20·73
	2,117	1,981	4,098	19·28

Returns showing the number of Births and the Birth Rate per mille per annum for each Nationality—*continued.*

1903.

	Males.	Females.	Total.	Birth Rate.
Europeans	27	26	53	14·53
Eurasians	66	39	105	25·20
Chinese	1,475	1,201	2,676	16·61
Malays	540	522	1,062	38·53
Indians	128	158	286	16·09
Others	40	37	77	27·14
	2,276	1,983	4,259	19·62

1904.

	Males.	Females.	Total.	Birth Rate.
Europeans...	31	38	69	18·74
Eurasians	79	71	150	35·51
Chinese	1,740	1,475	3,215	19·46
Malays	557	573	1,130	44·77
Indians	178	151	329	18·30
Others	36	29	65	22·22
	2,621	2,337	4,958	22·36

1905.

	Males.	Females.	Total.	Birth Rate.
Europeans	52	41	93	25·03
Eurasians	77	60	137	31·99
Chinese	1,789	1,444	3,233	19·09
Malays	666	603	1,269	45·23
Indians	158	165	323	17·77
Others	34	40	74	24·56
	2,776	2,353	5,129	22·66

INFANTILE MORTALITY.

TOTAL DEATHS.

Infants under One Year of Age.

1901.

	Number of Deaths.			Death Rate per 1,000.		
	Males.	Females.	Total.	Males.	Females.	Total.
Europeans	3	2	5	61·22	41·81	51·02
Eurasians	18	14	32	272·72	237·28	256·00
Chinese	458	377	835	375·40	350·04	363·51
Malays	176	176	352	411·21	392·85	401·82
Indians	62	45	107	340·65	330·88	336·47
Other nationalities	10	7	17	303·03	250·00	278·68
	727	621	1,348	367·54	345·57	357·08

1902.

	Number of Deaths.			Death Rate per 1,000.		
	Males.	Females.	Total.	Males.	Females.	Total.
Europeans	4	6	10	125·0	187·5	156·2
Eurasians	17	10	27	303·5	185·1	254·4
Chinese	463	435	898	337·7	356·8	346·7
Malays	186	159	345	421·7	331·2	374·5
Indians	59	32	91	318·9	187·2	255·6
Other nationalities	12	8	20	375·0	320·0	350·8
	741	650	1,391	349·5	328·1	339·4

1903.

	Number of Deaths.			Death Rate per 1,000.		
	Males.	Females.	Total.	Males.	Females.	Total.
Europeans	7	...	7	259·32	...	132·07
Eurasians	33	13	46	500·00	333·33	438·09
Chinese	503	426	929	341·01	354·70	347·15
Malays	218	177	395	403·70	339·08	372·07
Indians	73	64	137	570·31	405·06	479·02
Other nationalities	16	13	29	400·00	351 35	376·62
	850	693	1,543	374·34	349·42	362·29

TOTAL DEATHS.—CHILDREN UNDER ONE YEAR OF AGE—*continued.*

1904.

	Number of deaths.			Death Rate per 1,000.		
	Males.	Females.	Total.	Males.	Females.	Total.
Europeans	6	4	10	193·55	105·26	144·92
Eurasians	21	13	34	265·82	183·09	226·66
Chinese	564	490	1,054	324·13	332·20	327·83
Malays	187	177	364	317·77	308·90	322·12
Indians	65	52	117	365·16	344·37	355·60
Other nationalities	15	11	26	416·66	379·31	400·00
	858	747	1,605	327·35	320·49	337·03

1905.

	Number of deaths.			Death Rate per 1,000.		
	Males.	Females.	Total.	Males.	Females.	Total.
Europeans	7	3	10	134·61	73·17	107·52
Eurasians	33	18	51	428·57	300·00	372·26
Chinese	613	515	1,128	342·64	356 64	348·90
Malays	256	212	468	384·38	351·57	368·79
Indians	70	57	127	443·03	345·45	393·49
Other nationalities	17	9	26	500·00	225·00	351·35
	996	814	1,810	358·78	345·94	352·89

DEATHS FROM PARTICULAR DISEASES.

ENTERIC FEVER.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	11	4·51	...	...	11	3·07	All ages.
Eurasians	...	...	...	...	...	...	
Chinese	38	·31	3	·09	41	·26	
Malays	2	·12	...	...	2	·07	
Indians	...	...	...	...	...	...	
Other nationalities ...	...	...	...	...	...	...	
	51	·32	3	·05	54	·21	

TUBERCULAR DISEASES.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	4	1·65	...	...	4	1·11	All ages.
Eurasians	5	2·52	6	2·90	11	2·46	
Chinese	1,211	9·97	222	7·06	1,433	9·37	
Malays	81	5·81	53	4·55	134	4·91	
Indians	75	5·34	26	7·74	101	5·86	
Other nationalities ...	12	9·50	5	3·64	17	6·38	
	1,388	8·84	312	6·11	1,700	8·17	

DYSENTERY.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	6	2·48	...	...	6	1·67	All ages.
Eurasians	1	·50	2	·98	3	·74	
Chinese	162	1·34	9	·28	171	1·11	
Malays	7	·44	3	·25	10	·36	
Indians	42	2·56	6	1·78	48	2·76	
Other nationalities ...	3	2·37	...	...	3	1·12	
	221	1·42	20	·39	241	1·15	

DIARRHŒA, DYSENTERIC DIARRHŒA, CHOLERAIC DIARRHŒA.

1901.

	Males.		Females.		Total.		R-marks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	2	1·71	2	·55	All ages.
Eurasians	2	1·00	3	1·45	5	1·63	
Chinese	276	2·27	14	·44	290	1·89	
Malays	5	·31	5	·43	10	·36	
Indians	40	2·83	11	3·27	51	2·93	
Other nationalities ...	...	...	...	...	...	...	
	323	1·55	35	·17	358	1·72	

GASTRO ENTERITIS, BOWEL COMPLAINTS.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	4	1·65	1	·85	5	1·34	All ages.
Eurasians	6	3·02	6	2·90	12	3·93	
Chinese	111	·91	67	2 13	178	1·09	
Malays	13	·83	14	1·20	27	·98	
Indians	9	·64	10	2·97	19	1·09	
Other nationalities ...	2	1·58	4	2·85	6	2·25	
	145	·92	102	1·99	247	1·18	

BERI BERI.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	...	...	1	·27	All ages
Eurasians	...	...	1	·48	1	·32	
Chinese	1,038	8·54	74	2·35	1,112	7·27	
Malays	96	6·13	37	3·18	133	4·87	
Indians	51	3·63	14	5·01	65	3·68	
Other nationalities ...	4	3·10	3	2·14	7	2·63	
	1,190	7·50	129	2·52	1,319	6·34	

RESPIRATORY DISEASES.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	1	·85	2	·55	All ages.
Eurasians	9	4·50	6	2·90	15	4·91	
Chinese	281	2·30	131	4·16	412	2·69	
Malays	66	4·27	50	4·30	116	4·90	
Indians	41	2·80	13	3·84	54	3·10	
Other nationalities ...	6	4·70	1	·71	7	2·70	
	404	2·50	202	3·95	606	2·91	

CHOLERA.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	2	1·50	2	·96	4	1·31	
Chinese	93	·76	6	·18	99	·64	
Malays	9	·57	3	·24	12	·43	
Indians	3	·21	1	·30	4	·23	
Other nationalities ...	1	·79	...	...	1	·37	
	108	·62	12	·23	120	·57	

OTHER FEVERS NOT INCLUDING ENTERIC.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	...	...	1	·27	All ages.
Eurasians	...	...	...	...	...	...	
Chinese	38	·31	21	·66	59	·38	
Malays	3	·19	5	·43	8	·29	
Indians	5	·35	...	...	5	·28	
Other nationalities ...	...	...	...	...	...	...	
	47	·29	26	·50	73	·35	

MALARIAL DISEASES.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	2	·82	...	...	2	·55	All ages.
Eurasians	3	1 56	...	...	3	·98	
Chinese	1,262	10·39	168	5·34	1,430	9·35	
Malays	121	7·72	62	5·52	183	6·70	
Indians	110	7·80	17	5·09	127	7·30	
Other nationalities ...	4	3·16	...	...	4	1·50	
	1,502	9·57	247	4·80	1,749	8·41	

OTHER DISEASES.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	28	11·10	9	7·73	37	10·34	
Eurasians	30	15·07	25	12·09	55	14·75	
Chinese	1,577	12·98	470	14·96	2,047	13·32	
Malays	273	17·40	226	19·43	499	18·29	
Indians	187	13 34	67	19·95	254	14·60	
Other nationalities ...	20	15·84	9	6·43	29	10·89	
	2,115	13·40	806	15·79	2,921	14·05	

TOTAL DEATHS.

1901.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	58	23 21	13	11·18	71	19·86	
Eurasians	58	29·27	51	24·72	109	26·95	
Chinese	6,087	50 21	1,185	37·82	7,272	47·67	
Malays	676	43·17	458	39·43	1,134	41·61	
Indians	563	40 18	165	49·20	728	41·93	
Other naticnalities ...	52	40·54	22	15·78	74	27·91	
	7,494	47·87	1,894	37·20	9,388	45·25	

ENTERIC FEVER.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	3	1·23	2	1·68	5	1·48	All ages.
Eurasians	...	...	1	·47	1	·24	
Chinese	177	1·50	7	·21	184	1·17	
Malays	10	·63	5	·42	15	·55	
Indians	10	·70	...	...	10	·56	
Other nationalities ...	2	1·54	1	·68	3	1·09	
	202	1·26	16	·30	218	1·02	

TUBERCULAR DISEASES.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	9	3·71	3	2·52	12	3·33	All ages.
Eurasians	8	3·98	2	·95	10	2·43	
Chinese	1,332	10·70	205	6·30	1,537	9·79	
Malays	80	5·09	74	6·30	154	5·61	
Indians	79	5·60	24	7·07	103	5·85	
Other nationalties ...	11	8·50	4	2·74	15	5·46	
	1,519	9·49	312	5·90	1,831	8·61	

DYSENTERY AND CHOLERAIC DYSENTERY.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	3	1·23	1	·79	4	1·10	All ages.
Eurasians	...	...	4	1 90	4	·97	
Chinese	165	1·30	10	·30	175	1·11	
Malays	3	·18	3	·25	6	·21	
Indians	44	3·10	3	·88	47	2·60	
Other nationalties ...	3	2 32	1	·68	4	1·40	
	218	1·29	22	·41	240	1·12	

DIARRHŒA, DYSENTERIC DIARRHŒA AND CHOLERAIC DIARRHŒA.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	1	·84	2	·55	All ages.
Eurasians	1	·49	3	1·42	4	·97	
Chinese	327	2·60	23	·70	350	2·22	
Malays	11	·70	6	·51	17	·60	
Indians	20	1·40	5	1·47	25	1·40	
Other nationalities ...	4	3·09	1	·68	5	1·80	
	364	2·20	39	·70	403	1·89	

GASTRO-ENTERITIS AND BOWEL COMPLAINTS.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	2	1·68	3	·82	All ages.
Eurasians	4	1·99	...	...	4	·97	
Chinese	102	·81	53	1·62	155	·98	
Malays	30	1·90	19	1·60	49	1·07	
Indians	13	·91	7	2·06	20	1·13	
Other nationalities ...	5	3·86	1	·68	6	2·18	
	155	·96	82	1·50	237	1·11	

BERI BERI.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasions	3	1·44	1	·47	4	·97	
Chinese	803	6·45	53	1·62	856	5·40	
Malays	89	5·60	41	3·40	130	4·70	
Indians	58	4·80	7	2·06	65	3·69	
Other nationalities ...	4	3·09	6	4·12	10	3·70	
	957	5·90	108	2·06	1,065	5·01	

RESPIRATORY DISEASES.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	9	3·71	2	1·68	11	3·02	All ages.
Eurasians	7	3·48	5	2·40	12	2·90	
Chinese	276	2·20	122	3·70	398	2·50	
Malays	37	2·99	44	3·74	81	2·95	
Indians	28	1·97	12	3·50	40	2·20	
Other nationalities ...	5	3·86	6	4·12	11	4·00	
	362	2·20	191	3·60	553	2·50	

CHOLERA.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Derths.	Death Rate.	
Europeans	3	1·23	...	...	3	·82	All ages.
Eurasians	2	·95	1	·47	3	·73	
Chinese	605	4·80	21	·64	626	3·98	
Malays	39	2·40	34	2·90	73	2·60	
Indians	25	1·76	2	·50	27	1·50	
Other nationalities ...	4	3·09	1	·68	5	1·80	
	678	4·20	59	1·12	737	3·46	

OTHER FEVERS (NOT INCLUDING ENTERIC).

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	1	·79	1	·27	All ages.
Eurasians	...	...	2	·95	2	·48	
Chinese	147	1·18	19	·58	166	1·06	
Malays	12	·76	6	·51	18	·65	
Indians	7	·49	...	...	7	·39	
Other nationalities ...	...	...	...	...	...	...	
	166	1·03	28	·53	194	·91	

MALARIAL DISEASES.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	1	·79	2	·55	All ages.
Eurasians	3	1·44	4	1·90	7	1·70	
Chinese	1,489	11·90	175	5·37	1,664	10·51	
Malays	179	11·46	102	8·70	281	10·02	
Indians	143	10·07	20	5·89	163	9·27	
Other nationalities ...	11	8·50	3	2·06	14	5·09	
	1,826	11·40	305	5·82	2,131	10·03	

OTHER DISEASES.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	45	18·57	5	4·20	50	13·77	
Eurasians	28	13·43	29	13·62	57	13·87	
Chinese	1,781	14·31	625	19·21	2,406	15·26	
Malays	234	14·90	228	17·25	462	16·84	
Indians	184	12·81	60	17·69	244	13·80	
Other nationalities ...	15	11·62	17	11 67	32	11·64	
	2,287	14·10	964	18·40	3,251	15·30	

TOTAL DEATHS.

1902.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	75	30·96	18	15·13	93	25·75	
Eurasians	56	27·87	52	24·77	108	26·29	
Chinese	7,205	57·89	1,312	40·32	8,517	54·25	
Malays	724	45·48	562	47·93	1,286	46·89	
Indians	611	43·06	140	41·29	751	42·16	
Other nationalities ...	64	49·49	41	28·15	105	38·15	
	8,735	54·57	2,125	40·18	10,860	51·11	

ENTERIC FEVER.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·41	2	1·64	3	·82	All ages.
Eurasians	...	...	1	·46	1	·24	
Chinese	48	·37	4	·11	52	·32	
Malays	2	·12	2	·16	4	·14	
Indians	2	·13	...	...	2	·11	
Other nationalities ...	1	·75	1	·66	2	·70	
	54	·33	10	·18	64	·29	

TUBERCULAR DISEASES.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	6	2·46	1	·82	7	1·91	All ages.
Eurasians	5	2·45	10	4·69	15	4·11	
Chinese	1,090	8·60	213	6·30	1,303	8·08	
Malays	83	5·20	62	5·24	145	5·26	
Indians	78	5·40	25	7·50	103	5·70	
Other nationalities ...	12	9·06	15	9 90	27	9·51	
	1,274	7·80	326	6·06	1,600	7·37	

DYSENTERY.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	6	2·46	...	...	6	1·60	All ages.
Eurasians	5	2·45	2	·93	7	1·60	
Chinese	249	1·95	18	·53	267	1·65	
Malays	6	·38	2	·16	8	·29	
Indians	26	1·81	7	2·04	33	1·85	
Other nationalities ...	1	·75	1	·66	2	·70	
	293	1·10	30	·55	323	1·07	

DIARRHŒA, DYSENTERIC DIARRHŒA AND CHOLERAIC DIARRHŒA.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	4	1·96	2	·93	6	1·44	
Chinese	405	3·17	30	·88	435	2·70	
Malays	12	·76	4	·33	16	·58	
Indians	34	2·36	6	1·75	40	2·25	
Other nationalities...	1	·75	1	·66	2	·70	
	456	2·82	43	1·17	499	2·29	

GASTRO-ENTERITIS AND BOWEL COMPLAINTS.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	6	2·46	...	...	6	1·64	All ages.
Eurasians	10	4·91	5	2·34	15	3·62	
Chinese	86	·67	27	·80	113	·70	
Malays	9	·57	7	·59	16	·58	
Indians	14	·97	3	·87	17	·96	
Other nationalities ...	3	2·26	2	1·32	5	1·76	
	128	·78	44	·81	172	·79	

BERI BERI.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	2	·98	1	·46	3	·72	
Chinese	1,032	8·09	81	2·40	1,113	6·90	
Malays	87	5·43	38	3·21	125	4·53	
Indians	44	3·06	7	2·04	51	2·86	
Other nationalities ...	3	2 26	6	3·96	9	3·17	
	1,168	7·15	133	2·10	1,301	5·98	

RESPIRATORY DISEASES.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	4	1·64	1	·82	5	1·37	All ages.
Eurasians	13	6·38	6	2·81	19	4·56	
Chinese	440	3·45	156	4·62	596	3·69	
Malays	38	2·41	45	2·74	83	3·01	
Indians	43	2 99	11	3·20	54	3·03	
Other nationalities ...	6	4·53	3	1·98	9	3·17	
	544	3·33	222	4·13	766	3·52	

CHOLERA.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	
Eurasians	...	...	...	...	...	...	
Chinese	158	1·23	5	·14	163	1·01	
Malays	6	·38	4	·33	10	·36	
Indians	8	·56	2	·58	10	·56	
Other nationalities ...	1	·75	...	...	1	·35	
	173	1·05	11	·20	184	·84	

MALARIAL DISEASES.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	4	1·64	...	...	4	1·09	All ages.
Eurasians	3	1·47	1	·46	4	·96	
Chinese	1,100	8·63	139	4·13	1,239	7·69	
Malays	156	9·91	74	6·34	230	7·62	
Indians	73	5·08	10	2·92	83	4·72	
Other nationalities ...	5	3·77	4	2·64	9	3·17	
	1,341	8·21	228	4·24	1,569	7·22	

OTHER FEVERS (NOT INCLUDING ENTERIC).

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	41	1	·82	2	·54	All ages.
Eurasians	1	·49	2	·93	3	·72	
Chinese	248	1·94	94	2·56	342	2·12	
Malays	40	2·54	33	2·79	73	2·64	
Indians	25	1·74	15	4·38	40	2·25	
Other nationalities ...	2	1·51	1	·66	3	1·05	
	317	1·94	146	2·71	463	2·13	

OTHER DISEASES.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	32	13·15	11	9·06	43	11·24	All ages.
Eurasians	35	17·19	31	14·54	66	15·84	
Chinese	1,721	13·50	608	18·06	2,329	14·45	
Malays	287	18·54	252	21·31	539	19·59	
Indians	201	14·28	94	27·43	295	16·59	
Other nationalities ...	26	19·63	18	11·89	44	15·50	
	2,302	14·90	1,014	18·86	3,316	15·23	

TOTAL DEATHS.

1903.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	60	24·67	16	13·17	76	20·84	All ages.
Eurasians	78	38·32	61	28·62	139	33·36	
Chinese	6,577	51·62	1,375	40 86	7,952	49·36	
Malays	726	46·13	523	44·23	1,249	45·32	
Indians	548	38·18	180	52·58	728	41·52	
Other nationalities ...	61	46·08	52	34·36	113	39·83	
	8,050	49·29	2,207	41·05	10,257	47·25	

ENTERIC FEVER.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	2	·81	1	·80	3	·81	All ages.
Eurasians	2	·96	...	...	2	·47	
Chinese	55	·42	5	·14	60	·36	
Malays	1	·62	...	...	1	·03	
Indians	2	·13	...	...	2	·92	
Other nationalities ...	...	...	2	1·27	2	·68	
	62	·37	8	·14	70	·31	

TUBERCULAR DISEASES.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans ...	9	3·60	1	·80	10	2·71	All ages.
Eurasians	3	1·45	4	1·84	7	1·65	
Chinese	1,074	8·23	203	5·83	1,277	7·73	
Malays	79	5·14	56	4·69	135	4·87	
Indians	60	4·13	22	6·36	82	4·56	
Other nationalities ...	11	8·11	11	7·00	22	7·52	
	1,236	7·41	297	5·38	1,533	6·94	

DYSENTERY.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	4	1·63	5	4·03	9	2·44	All ages.
Eurasians	1	·48	...	...	1	·23	
Chinese	211	1·61	19	·54	230	1·39	
Malays	10	·63	2	·16	12	·43	
Indians	32	2·20	3	·86	35	1·81	
Other nationalities ...	2	1·47	...	...	2	·68	
	260	1·56	29	·52	289	1·30	

DIARRHŒA.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	2	·97	...	...	2	·47	
Chinese	307	2·35	37	1·06	344	2·08	
Malays	10	·63	5	·41	15	·54	
Indians	27	1·86	4	1·15	31	1·72	
Other nationalities ...	2	1·47	3	1·91	5	1·70	
	348	2·08	49	·88	397	1·79	

GASTRO-ENTERITIS AND BOWEL COMPLAINTS.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	...	...	1	·27	All ages.
Eurasians	2	·97	3	1·38	5	1·18	
Chinese	73	·55	30	·86	103	·62	
Malays	9	·50	8	·67	17	·61	
Indians	10	·68	6	1·73	16	·89	
Other nationalities ...	1	·73	1	·63	2	·68	
	96	·63	48	·87	144	·64	

BERI BERI.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	...	...	1	·27	All ages.
Eurasians	1	·48	...	...	1	·23	
Chinese	1,210	9·27	71	2·04	1,281	7·89	
Malays	128	8·11	51	1·46	179	6·46	
Indians	48	3·30	13	3·76	61	3·39	
Other nationalities ...	8	5·91	7	4·45	15	5·12	
	1,396	8·38	142	9·46	1,538	6·93	

RESPIRATORY DISEASES.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	2	·81	1	·80	3	·81	All ages.
Eurasians	10	4·85	4	1·84	14	3·31	
Chinese	483	3·70	161	4·63	644	3·89	
Malays	51	3·23	39	3·27	90	3·28	
Indians	38	2·61	16	4·62	54	2·00	
Other nationalities ...	1	·73	2	1·27	3	1·02	
	585	3·51	223	4·04	808	3·64	

CHOLERA.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	...	...	...	...	...	...	
Chinese	3	·02	...	...	3	·01	
Malays	...	...	...	...	...	...	
Indians	...	...	...	...	...	...	
Other nationalities ...	...	...	...	...	...	...	
	3	·01	...	...	3	·01	

OTHER FEVERS (NOT INCLUDING ENTERIC).

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	1	·80	1	·27	All ages.
Eurasians	7	3·39	3	1·38	10	2·36	
Chinese	315	2·41	112	3·22	427	2·58	
Malays	37	2·34	28	2·34	65	2·34	
Indians	17	1·17	8	2·31	25	1.39	
Other nationalities ...	2	1·40	2	1·27	4	1·38	
	378	2·26	154	2·79	532	2·39	

MALARIAL DISEASES.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	6	2·45	...	...	6	1·63	All ages.
Eurasians	2	·97	2	·92	4	·94	
Chinese	1,203	9·22	132	3·76	1,335	8·08	
Malays	166	9·88	78	6·54	244	8·80	
Indians	69	4·75	22	6·36	91	5·06	
Other nationalities ...	8	5·90	5	3·18	13	4·44	
	1,454	8·72	239	4·33	1,693	7·63	

OTHER DISEASES.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	43	1·76	5	4·83	48	13·03	
Eurasians	25	12·13	23	10·63	48	11·36	
Chinese	1,446	11·08	644	18·52	2,090	12·65	
Malays	219	13·24	189	15·85	408	14·73	
Indians	159	10·95	85	24·59	244	13·55	
Other nationalities ...	30	22·14	18	11·46	48	16·41	
	1,922	17·54	964	17·49	2,886	13·01	

TOTAL DEATHS.

1904.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	68	27·84	14	11·29	82	22·27	
Eurasians	55	26·68	39	18·03	94	22·25	
Chinese	6,380	48·91	1,414	40·67	7,794	47·18	
Malays	710	45·01	456	38·24	1,166	42·09	
Indians	462	31·83	179	51·79	641	35·67	
Other nationalities ...	65	47·97	51	32·48	116	39·65	
	7,740	46·46	2,153	39·64	9,893	44·62	

ENTERIC FEVER.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	...	...	1	·26	All ages.
Eurasians	1	·47	...	...	1	·23	
Chinese	80	·59	8	·25	88	·51	
Malays	...	...	...	...	...	...	
Indians	1	·07	2	·57	3	·16	
Other nationalities ...	1	·72	1	·61	2	·66	
	84	·49	11	·19	95	·41	

TUBERCULAR DISEASES.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	7	2·85	...	...	7	1·88	All ages.
Eurasians	9	4·31	9	4·10	18	4·20	
Chinese	1,340	10·04	223	6·21	1,563	9·23	
Malays	70	4·42	59	4·90	129	4·63	
Indians	67	4·56	36	1·31	103	5·67	
Other nationalities ...	18	12·99	14	8·60	32	10·62	
	1,511	8·89	341	6·03	1,852	8·18	

DYSENTERY.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	1	·79	2	·51	All ages.
Eurasians	5	2·39	3	1·36	8	1·86	
Chinese	297	2·22	20	·55	317	1·87	
Malays	7	·44	...	...	7	·25	
Indians	38	2·58	1	·28	39	2·14	
Other nationalities ...	4	2·88	...	...	4	1·32	
	352	2·07	25	·44	377	1·66	

DIARRHŒA, CHOLERAIC DIARRHŒA.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	1	·79	1	·26	All ages.
Eurasians	2	·90	4	1·82	6	1·40	
Chinese	266	1·99	42	1·17	308	1·81	
Malays	11	·69	10	·83	21	·75	
Indians	23	1·56	4	1·14	27	1·48	
Other nationalities ...	3	2·17	3	1·84	6	1·99	
	305	1·79	64	1·13	369	1·63	

GASTRO-ENTERITIS AND BOWEL COMPLAINTS.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	5	2·03	1	·79	6	1·61	All ages.
Eurasians	6	2·87	3	1·35	9	2·10	
Chinese	82	·61	39	1·08	121	·71	
Malays	7	·44	12	·99	19	·68	
Indians	20	1·36	5	1·43	25	1·37	
Other nationalities ...	1	·72	1	·61	2	·66	
	121	·71	61	1·08	182	·80	

BERI BERI.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	1	·47	...	...	1	·23	
Chinese	887	6·64	68	1·89	955	5·67	
Malays	104	6·57	51	4·23	155	5·56	
Indians	31	2·11	9	2·26	40	2·20	
Other nationalities ...	10	7·22	2	1·22	12	3·98	
	1,033	6·08	130	2·03	1,163	5·13	

RESPIRATORY DISEASES.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	1	·40	...	...	1	·26	All ages.
Eurasians	3	1·43	2	·91	5	1·16	
Chinese	614	4·60	235	6·55	849	5·60	
Malays	72	4·55	56	4·65	128	4·60	
Indians	42	2·86	21	6·01	63	3·46	
Other nationalities ...	4	2·88	3	1·84	7	2·32	
	736	4·33	317	5·61	1,053	4·62	

CHOLERA.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	...	...	...	...	...	...	All ages.
Eurasians	1	·47	...	...	1	·23	
Chinese	11	·08	...	...	11	·06	
Malays	...	...	...	...	...	...	
Indians	3	·20	...	...	3	·16	
Other nationalities ...	...	...	...	...	...	...	
	15	·08	...	...	15	·06	

OTHER FEVERS (NOT INCLUDING ENTERIC).

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	2	·81	...	...	2	·53	All ages.
Eurasians	6	2·87	3	1·36	9	2·10	
Chinese	613	4·59	150	4·18	763	4·50	
Malays	84	5·31	47	3·90	131	4·70	
Indians	40	2·72	23	6·59	63	3·46	
Other nationalities ...	6	4·32	3	1·84	9	2·98	
	751	4·42	226	4·00	977	4·32	

MALARIAL DISEASES.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	3	1·22	...	...	3	·80	All ages.
Eurasians	2	·90	2	·91	4	·93	
Chinese	337	2·52	61	1·70	398	2·35	
Malays	33	2·08	17	1·41	50	1·79	
Indians	40	2·71	6	1·71	46	2·53	
Other nationalities ...	1	·72	1	·61	2	·66	
	416	2·44	87	1·54	503	2·22	

OTHER DISEASES.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	40	16·39	11	8·70	51	13·72	
Eurasians	47	22·52	30	13·66	77	17·98	
Chinese	1,538	11·52	690	19·23	2,228	13·16	
Malays	330	20·87	280	23·28	610	21·91	
Indians	202	13·76	79	22·64	281	15·46	
Other nationalities ...	40	28·86	28	17·20	68	22·56	
	2,197	12·93	1,118	19·79	3,315	14·65	

TOTAL DEATHS.

1905.

	Males.		Females.		Total.		Remarks.
	Deaths.	Death Rate.	Deaths.	Death Rate.	Deaths.	Death Rate.	
Europeans	60	24·46	14	11·07	74	19·91	
Eurasians	83	39·77	56	25·51	139	32·46	
Chinese	6,065	45·45	1,536	42·81	7,601	44·89	
Malays	718	45·50	532	44·24	1,250	44·90	
Indians	504	34·34	189	54·17	693	38·15	
Other nationalities ...	88	63·49	56	34·41	144	47·79	
	7,518	44·26	2,383	42·19	9,901	43·74	

VITAL STATISTICS RELATING TO THE TROOPS.

EUROPEAN TROOPS.

RETURN OF ADMISSIONS AND DEATHS AMONG WARRANT OFFICERS, NON-COMMISSIONED OFFICERS, AND MEN, OF THE EUROPEAN TROOPS STATIONED AT SINGAPORE, STRAITS SETTLEMENTS, DURING THE ELEVEN YEARS, 1895–1905.

Disease.	1905. Average Annual Strength, 1,465. Admissions. No.	1905. Average Annual Strength, 1,465. Admissions. Ratio per 1,000 of Strength.	1905. Average Annual Strength, 1,465. Deaths. No.	1905. Average Annual Strength, 1,465. Deaths. Ratio per 1,000 of Strength.	1895–1904. Average Annual Strength, 1,049. Admissions. No. in 10 years.	1895–1904. Average Annual Strength, 1,049. Admissions. Average Annual Ratio per 1,000 of Strength for 10 years.	1895–1904. Average Annual Strength, 1,049. Deaths. No. in 10 years.	1895–1904. Average Annual Strength, 1,049. Deaths. Average Annual Ratio per 1,000 of Strength for 10 years.
Enteric Fever ...	1	0·68	...	...	10	0·95	5	0·48
Cholera	...	...	...	...	1	0·10	1	0·10
Dysentery	2	1·37	...	...	43	4·10	1	0 10
Malarial Fever ...	476	324·91	2	1·37	4,273	407·34	17	1·62
Tubercle of Lung ...	3	2·04	...	...	28	2·67	5	0 48
Other Tubercular Diseases	2	1·37	...	...				
Other Diseases and Injuries	968	660·75	9	6·14	8,738	832·98	59	5·61
Total	1,452	991·12	11	7·51	13,093	1,248·14	88	8·39

REMARKS.

1. The deaths, shown in the above Return, for the year 1905, do not include the deaths among 51 invalids sent to England during that year. Information as to the number of deaths among such invalids, after the latter left Singapore, will not be received from the War Office, until the beginning of 1907.

2. The deaths, shown in the above Return, for the ten years 1895-1904, include the deaths among 293 invalids sent to England, after the latter had left Singapore.

3. There were no cases of Beri-Beri during the six years 1900–1905.

4. In 1905 there were 14 admissions with diarrhœa, equivalent to a ratio of 9·56 per 1,000 of strength, compared with 44 admissions during the preceding five years, equivalent to an average annual ratio of 12·37 per 1,000 of strength. There were no deaths from this disease during the six years 1900–1905.

In the foregoing Return, diarrhœa is included under "Other Diseases and Injuries," as statistics for this disease, as well as for Beri-Beri, are not available for the whole decennial period 1895–1904.

5. Since November, 1903, a large number of mild cases of sickness have been treated in barracks, many of which, previous to November, 1903, would have been admitted into hospital. These cases are not included in this Return, and, in consequence, the lower admission ratio in 1905, as compared with that of the preceding 10 years, is more apparent than real.

H. H. JOHNSTON,
Lieut.-Colonel R.A.M.C., S.M.O., S.S.

FORT CANNING, SINGAPORE.
27th July, 1906.

ASIATIC TROOPS.

Return of Admissions and Deaths among Warrant Officers, Non-Commissioned Officers and Men of the Asiatic Troops stationed at Singapore, Straits Settlements, during the Six Years 1900–1905.

Disease.	1905. Average Annual Strength, 932.				1900-1904. Average Annual Strength, 1,045.			
	Admissions.		Deaths.		Admissions.		Deaths.	
	No.	Ratio per 1,000 of Strength.	No.	Ratio per 1,000 of Strength.	No.	Average Annual Ratio per 1,000 of Strength.	No.	Average Annual Ratio per 1,000 of Strength.
Enteric Fever	...	...	...	...	1	0·19	...	...
Cholera	...	...	...	...	4	0·77	4	0·77
Dysentery	100	107·30	1	1·07	212	40·57	4	0·77
Beri Beri	1	1·07	1	1·07	106	20·29	2	0·38
Malarial Fever ...	190	203·86	...	...	775	148·33	8	1·53
Tubercle of Lung ...	3	3·22	1	1·07	11	2·11	1	0·19
Other Tubercular Diseases	...	...	...	...	1	0·19	1	0·19
Diarhœa	10	10·73	...	...	51	9·76	...	...
Other Diseases and Injuries	360	386·27	2	2·15	1,760	336·84	18	3·44
Total ...	664	712·45	5	5·36	2,921	559·05	38	7·27

REMARKS.

1. The deaths shown in the above Return do not include deaths among 25 invalids sent to India in 1905, nor among 84 invalids sent to India during the five years 1900-1904, after the invalids had left Singapore.

2. Of the 25 invalids sent to India in 1905, seven died in India, viz. :—1 from dysentery, 8 from malarial fever, and 5 from other diseases. The number of deaths among the 84 invalids sent to India during 1900-1904 has not been recorded.

H. H. JOHNSTON,
Lt.-Colonel, R.A.M.C., S.M.O., S.S.

Fort Canning, Singapore,
27th July, 1906.

ASIATIC TROOPS.

Return of Admissions and Deaths from Dysentery, among the 95th Russell's Infantry, Alexandra Barracks, Singapore.

1905.

Admissions into Hospital.	Deaths.	Remarks.
January 1	...	The 95th Russell's Infantry arrived at Singapore from India, on 10th January, 1905.
February 6	...	
March	...	
April 2	...	
May 14	...	1 died in September, 1905, in India, when on sick leave with dysentery from Singapore.
June 16	...	
July 3	...	1 died in November, 1905, at Singapore.
August 2	..	
September 2	1	Died in India, when on sick leave with dysentery from Singapore.
October 3	...	1 died in January, 1906, at Singapore.
November 34	1	Died at Singapore.
December 16	...	
Total 99	2	3 died, 2 in 1905 and 1 in 1906.

1906.

Admissions into Hospital.	Deaths.	Remarks.
January 2	1	Died at Singapore, admitted in October, 1905.
February	...	
March 2	...	
April	..	
May 2	...	
June 1	...	
July	...	
August	...	
September	...	
October	...	
November	...	
December	...	
Total	...	

H. H. JOHNSTON,

Lt.-Colonel, R.A.M.C., S.M.O., S.S.

Fort Canning, Singapore,
27th July, 1906.

EUROPEAN TROOPS.

Return of Cases of Malarial Fever among the European Troops and their Families, at Singapore, Straits Settlements, during the Year 1905.

BLAKAN MATI AND PASSIR PANJANG.

Class.	Average Annual Strength.	Cases of Malarial Fever.		Deaths from Malarial Fever.	
		No.	Ratio per 1,000 of Strength.	No.	Ratio per 1,000 of Strength.
Officers	10	...	...	...	...
Warrant Officers, Non-Commissioned Officers and Men	366	314*	857·92	...	...
Women	17	2	117·65	...	...
Children	29	5	172·41	...	...
Total	422	321	760·66	...	...

PULAU BRANI.

Officers	8	1	125·00	...	...
Warrant Officers, Non-Commissioned Officers and Men	111	151†	1360·36	2	18·02
Women	11	14	1272·73	1	90·91
Children	18	10	555·56	...	...
Total	148	176	1189·19	3	20·27

FORT CANNING, FORT PALMER AND PEARLS HILL.

Officers	14	2	142·85	...	...
Warrant Officers, Non-Commissioned Officers and Men	48	4‡	83·33	...	...
Women	11	...	...	...	...
Children	16	...	...	...	...
Total	89	6	67·42	...	...

TANGLIN AND NORMANTON BARRACKS.

Officers	19	2	105·26	...	...
Warrant Officers, Non-Commissioned Officers and Men	940	136§	144·68	...	...
Women	22	...	...	...	...
Children	29	2	68·97	...	...
Total	1,010	140	138·61	...	...

EUROPEAN TROOPS.—RETURN OF CASES OF MALARIAL FEVER—*continued.*

TOTAL.

Class.	Average Annual Srength.	Cases of Malarial Fever.		Deaths from Malarial Fever.	
		No.	Ratio per 1,000 of Strength.	No.	Ratio per 1,000 of Strength.
Officers	51	5	98·04	...	...
Warrant Officers, Non-Commissioned Officers and Men	1,465	605‖	412·97	2	1·36
Women	61	16	262·30	1	16·39
Children	92	17	184·78	...	...
Total	1,669	643	385·26	3	1·77

* Includes 253 patients admitted into hospital, and 61 men treated in barracks.
† „ 91 „ „ „ 60 „ „
‡ „ 1 „ „ „ 3 „ „
§ „ 131 „ „ „ 5 „ „
‖ „ 476 „ „ „ 129 „ „

NOTE.—At Tanglin, in addition to the 136 cases of malarial fever among Warrant Officers, Non-Commissioned Officers, and Men, there were 99 cases (88 patients admitted into hospital, and 11 men treated in barracks) of "Simple continued Fever," but no cases of the latter disease were recorded at the other stations mentioned above. With reference to the cases of "Simple continued Fever" at Tanglin, Major J. Ritchie, R.A.M.C., reports as follows: "The duration of these cases was short, and blood examination showed the presence of no malarial parasite."

H. H. JOHNSTON.
Lieut-Colonel, R.A.M.C., S.M.O., S.S.

FORT CANNING, SINGAPORE.
27th July, 1906.

ASIATIC TROOPS.

RETURN OF CASES OF MALARIAL FEVER AMONG THE ASIATIC TROOPS, AT SINGAPORE, STRAITS SETTLEMENTS, DURING THE YEAR 1905.

Station.	Average Annual Strength.	Cases of Malarial Fever.		Deaths from Malarial Fever.	
		No.	Ratio per 1,000 of strength.	No.	Ratio per 1,000 of strength.
Blakan Mati and Fort Passir Panjang	...	...	...	...	...
Pulau Brani...	40	72*	1800·00	...	...
Fort Canning	193	64†	331·61	...	...
Tanglin and Normanton Barracks	...	...	...	...	...
Alexandra Barracks ...	710	142‡	200·00	...	...
Total	943	278§	294·80	...	...

* Includes 14 patients admitted into hospital and 58 men treated in barracks.
† „ 34 „ „ „ 30 „ „ „
‡ „ 142 patients admitted into hospital.
§ „ 190 „ „ „ 88 „ „ „

In addition to the average annual strength of 943 Asiatic Troops, there was an average annual strength of 29 Asiatic women and 25 Asiatic children at Pulau Brani, and 8 Asiatic women and 8 Asiatic children at Fort Canning, but no record of malarial fever cases, among the families of Asiatic Troops, was kept during the year 1905.

There were no Asiatic women and children at Alexandra Barracks.

H. H. JOHNSTON,
Lieut.-Colonel, R.A.M.C., S.M.O., S.S.

FORT CANNING, SINGAPORE,
21st August, 1906.

STATISTICS FROM THE ADMISSION BOOKS OF THE GENERAL HOSPITAL, SINGAPORE, TO SHOW THE COMPARISON BETWEEN THE ADMISSIONS FOR TUBERCULAR DISEASE DURING A PERIOD OF ONE YEAR, AT THE PRESENT TIME, AND SOME YEARS AGO.

EUROPEAN WARDS.

	1893.	June 1st, 1905—May 31st, 1906.
Total Number admitted for all diseases ...	659	577
" " " tubercular disease	24 { Males 20 Females 4	19 { Males 12 Females 7
Percentage of admissions for tubercle to total	3·94 per cent.	3·29 per cent.
NATIONALITIES OF ADMISSION FOR TUBERCLE:—		
English	7	4
Eura-ian	4	4
Scotch	3	1
French	3	2
American...	2	...
Chinese	1	2
Armenian	1	...
Japanese	1	2
Russian	1	...
Greek	1	...
Tamil	...	1
Swede	...	1
Irish	...	1
Papuan	...	1
Total	24	19
NATURE OF TUBERCULAR DISEASE :—		
Tubercle of Lungs	21	11
Pleurisy	2	3
Scrofula	1	...
Pyopneumothorax	...	1
Tubercular disease of knee	...	3 { French female, 1 Irish " 1 Eurasian " 1
Tubercular peritonitis and pleurisy ...	...	1 (Japanese female)
Total	24	19
Landed from ships	12	5
Remainder	12	14

Statistics from the Admission Books of the General Hospital, Singapore—*continued.*

NATIVE WARDS.

	June 1st, 1891—May 31st, 1892.	June 1st, 1905—May 31st, 1906.
Total Number admitted for all diseases ...	1,666	2,247
„ „ „ tubercular diseases	21 { Males 19 / Females 2	77 { Males 67 / Females 10
Percentage of admissions for tubercle to total	1·20 per cent.	3·42 per cent.
Nationalities of Admissions for Tubercle:—		
Chinese	7	44
Tamil	7	11
Bengali and Sikh	1	13 { Bengali 8 / Sikh 5
Singhalese	1	1
Japanese	2	4
Boyanese	1	...
Malay	...	2
Malabar	1	...
Manila	1	...
Arab	...	1
Eurasian	...	1
Total	21	77
Nature of Tubercular Disease:—		
Tubercle of Lungs	16	52
Pleurisy	1	3
Empyema	1	...
General Tuberculosis	3	6
Tubercular Glands	...	4
„ Abscesses	...	3
„ Sinus	...	1
„ Enteritis	...	2 { Bengali Males 1 / Sikh „ 1
„ Meningitis	...	1 (Chinese male)
„ Osteitis	...	1 („ female)
„ Arthritis	...	4 { Chinese male 1 / „ female 1 / Japanese female 1 / Bengali male 1
Total	21	77
Occupations:—	Not stated in admission book.	
Riksha pullers		11
Sinkehs (New arrivals from China) ...		9
Watchmen		6
Clerks		5
Teachers		4
Tailors		3
Municipal road sweepers		3
Milk sellers		1
Cake sellers		1
Pork sellers		1
Occupation given as nil		12
Other occupations		21
Total		77

STATISTICS FROM THE ADMISSION BOOKS OF THE GENERAL HOSPITAL, SINGAPORE—*continued.*

NATIVE POLICE WARD.

	1892.	1905.
Total Number admitted for all diseases ...	522	413
" " " tubercular diseases...	4	3
Percentage of admissions for tubercle to total	·76	·72
NATIONALITIES :—		
Chinese	1	1
Tamil	2	1
Bengali	1	...
Malay	...	1
Total	4	3
NATURE OF TUBERCULAR DISEASE :—		
Tubercle of Lungs	3	2
Pleurisy and Effusion	1	...
Caries of Spine	...	1
Total	4	3

APPENDIX B.

ANALYSES OF WATER SUPPLY.

(*a*) CHEMICAL ANALYSIS OF WATER.

I. SERIES.

12-7-06.

SEVEN SAMPLES FROM THE IMPOUNDING RESERVOIR.

Samples.	Main Feeder above 2nd Bridge.	Side Feeder above workmen.	Side Feeder below workmen.	Feeder past Kallang Tunnel.	Main Feeder between 1st and 2nd Bridges.	Rice marsh.	Reservoir near Outlet Tower.
Colour in 2 ft. tube ...	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque	Brown
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grs. per gallon)	·28	·28	·7	·35	·28	·35	·35
Total Solids do.	4·3	13·2	136·4	9·6	11·9	6·0	6·6
Total organic solids do.	1·3	2·4	27·0	2·6	2·6	1·7	5·2
Free Ammonia (parts per million)	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Albuminoid Ammonia (parts per million) ...	*Nil.*	*Nil.*	1·36	·030	·036	·050	·122
Nitrates as Ammonia (parts per million) ...	·480	·380	·480	·280	·280	·200	·120
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·024	·335	4·29	*Nil.*	*Nil.*	*Nil.*	*Nil.*

II. SERIES.

16-7-06.

SEVEN SAMPLES FROM THE FILTER BEDS.

Samples.	Filter No. 2. 27 hours 2nd day.	Filter No. 3. 74 hours 4th day.	Filter No. 6. 27 hours 2nd day.	Unfiltered. Tap of Filter No. 6.	Filter No. 7. 1½ hours.	Filter No. 8. 4th day.	Filter No. 12. 4th day.
Colour in 2 ft. tube ...	Clear.	Clear.	Clear.	Brown.	Clear.	Clear.	Clear.
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grs. per gallon)	·28	·28	·35	·35	·35	·28	·28
Total Solids do.	6·1	3·1	?	6·5	3·4	4·1	3·6
Total Organic Solids do.	4·8	2·2	?	4·5	2·4	3·0	1·9
Free Ammonia (parts per million	*Nil.*	*Nil.*	*Nil.*	·070	*Nil.*	*Nil.*	*Nil.*
Albuminoid Ammonia (parts per million) ..	*Nil.*	*Nil.*	*Nil.*	·116	·036	*Nil.*	*Nil.*
Nitrates, as Ammonia (parts per million) ...	·070	·130	·100	·030	·090	·040	·120
Nitrites, as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·139	*Nil.*	·172	·122	·122	·108	·115

III. SERIES.

16-7-06.

THREE SAMPLES FROM MT. EMILY.

Samples.	Clear water tank at filter beds.	Sample from pump well No. 2 Low Level Reservoir.	High Level Reservoir, Mt. Emily.
Colour in 2-feet tube	Light Brown	Brown	Light Brown
Smell	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·31	·35	·35
Total Solids (grains per gallon)	3·0	6·6	4·0
Total Organic Solids (grains per gallon)...	0·6	3·0	1·6
Free Ammonia (parts per million) ...	·046	·050	·046
Albuminoid Ammonia (parts per million)	·096	·106	·130
Nitrates as Ammonia (parts per million)	*Nil.*	·050	·204
Nitrites as Ammonia (parts per million)	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·186	·164	·157

IV. SERIES.

16-7-06.

FOUR SAMPLES.

Samples.	Sample from tap in Laboratory.	Sample from tap in dark room of Laboratory after standing a fortnight.	Sample from standpipe near Ellenborough Market.	Sample from Pearl's Hill Reservoir.
Colour in 2 ft. tube	Brown	Opaque	Brown	Brown
Smell	*Nil.*	Foul	*Nil.*	*Nil.*
Chlorine (grains per gallon)...	·35	·35	·35	·35
Total Solids (grains per gallon)	5·3	6·6	3·2	2·6
Total Organic Solids (grains per gallon) ...	2·4	2·1	1·4	2·4
Free Ammonia (parts per million)	·016	·040	·030	·070
Albuminoid Ammonia (parts per million) ...	·076	·130	·076	·130
Nitrates as Ammonia (parts per million) ..	·100	*Nil.*	·060	·190
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per million) ...	·193	·193	·193	·164

V. SERIES.

25-7-06.

THREE SAMPLES FROM FILTER BEDS.

Samples.	Clear water tank of filter No. 5 trickling through side wall.	Drain from septic tank.	Manhole drain from hill.
Colour in 2 ft. tube	Clear	Clear.	Clear.
Smell	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·49	·42	·63
Total Solids do.	4·3	8·1	3·8
Total Organic Solids (grains per gallon) ...	2·1	2·4	2·3
Free Ammonia (parts per million) ...	*Nil.*	·010	·024
Albuminoid Ammonia do. ...	·040	·160	·020
Nitrates as Ammonia do. ...	·210	·190	·240
Nitrites as Ammonia do. ...	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	*Nil*	*Nil.*	*Nil.*

VI. SERIES.

27-7-06.

FOUR SAMPLES FROM MT. EMILY AND DISTRICT.

Samples.	Mt. Emily Reservoir.	Tap in house, 20-17, Armenian Street.	Hydrant in Selegu Road, near Municipal Water Supply Office.	Standpipe, Thompson Road (dead end).
Colour in 2 ft. tube	Brown Opaque.	Brown Opaque.	Brown slightly Opaque.	Brown Opaque.
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·42	·42	·42	·42
Total Solids (grains per gallon)	3·6	3·2	3·3	4·6
Total Organic Solids (grains per gallon) ...	2·0	1·4	1·8	2·5
Free Ammonia (parts per million)	·066	·036	·052	·020
Albuminoid Ammonia (parts per million) ...	·120	·106	·092	·080
Nitrates as Ammonia (parts per million) ...	·164	·194	·258	·260
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·130	·113	·066	·139

VII. SERIES.

27-7-06.

FOUR SAMPLES FROM PEARL'S HILL AND DISTRICT.

Samples.	Pearl's Hill Reservoir.	Tap in Raffles Square.	Tap in house, 84, Teluk Ayer Street.	Hydrant in Wallich Street.
Colour in 2ft. tube	Brown.	Brown.	Brown opaque	Brown opaque
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)...	·35	·35	·35	·35
Total Solids (grains per gallon)	4·5	4·0	4·3	4·7
Total Organic Solids (grains per gallon) ...	3·3	2·7	1·6	2·8
Free Ammonia (parts per million)	·062	·052	·026	·056
Albuminoid Ammonia (parts per million) ...	·082	·106	·046	·110
Nitrates as Ammonia (parts per million) ...	·198	·158	·164	·174
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	*Nil.*	*Nil.*	·019	·047

VIII.—SERIES.

31-7-06.

SIXTEEN SAMPLES FROM THE FILTERS.

SAMPLES.	Filter No. 2.		Filter No. 3.		Filter No. 6.		Filter No. 7.		Filter No. 8.		Filter No. 9.		Filter No. 11.		Filter No. 12.	
	2 days.		3 days.		2 days.		4 days.		3 days.		3 days.		4 days.		1 day.	
	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.
Colour in 2 in. Tube	Brown Opaque	Clear	Brown Opaque	Clear	Brown Opaque	Clear	Brown	Clear	Brown	Clear	Brown	Clear	Brown	Clear	Brown	Clear
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·42	·42	·35	·42	·35	·35	·42	·42	·42	·35	·35	·42	·28	·35	·35	·42
Total Solids (grains per gallon)	3·7	2·9	2·8	3·4	2·8	1·7	3·9	3·3	2·2	3·1	4·7	3·5	5·2	3·4	6·0	2·1
Total Organic Solids (grains per gallon)	2·0	1·6	1·7	1·9	1·8	·7	2·8	3·1	1·4	2·5	2·6	2·3	3·7	2·3	3·3	1·7
Free Ammonia (parts per million)	·080	*Nil.*	·050	·046	·040	*Nil.*	·044	·020	·072	·006	·046	·016	·046	·004	·056	*Nil.*
Albuminoid Ammonia (parts per million)	·186	*Nil.*	·140	·046	·150	*Nil.*	·156	·036	·122	·042	·142	·036	·116	·026	·116	·024
Nitrates as Ammonia (parts per million)	·160	·500	*Nil.*	·514	·260	·460	·156	·240	·108	·494	·114	·244	*Nil.*	·296	·144	·560
Nitrites as Ammonia (parts per million)	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000)	·082	·052	·076	*Nil.*	·045	·085	·060	·060	·063	·041	·071	·029	·079	·068	·057	*Nil.*

IX. SERIES.

3-8-06.

FOUR SAMPLES FROM IMPOUNDING RESERVOIR.

Samples.	Impounding Reservoir on surface near Outlet Tower.	Impounding Reservoir near Outlet Tower.		
		4 ft. below surface.	9 ft. below surface.	14 ft. below surface.
Temperature at time of taking samples ...	86°F.	85°F.	84·1°F.	82·1°F.
Colour in 2 ft. tube	Brown opaque	Brown opaque	Brown opaque	Brown opaque
Chlorine (grains per gallon)...	·35	·42	·42	·42
Total Solids (grains per gallon)	2·3	2·8	6·4	5·7
Total Organic Solids (grains per gallon) ...	1·2	1·9	4·5	3·1
Free Ammonia (parts per million)	·200	·024	·076	·216
Albuminoid Ammonia (parts per million)...	·206	·156	·122	·108
Nitrates as Ammonia (parts per million) ...	*Nil.*	·036	·124	·244
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·019	·114	·052	·063
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*

X. SERIES.

3-8-06.

FIVE SAMPLES FROM FILTER BEDS.

Samples.	Main near inlet of Filter No. 2.	Clear water tank.		Low-level Reservoir.	Pump-well.
		Inlet.	Outlet.		
Temperature at time of taking samples	85° F.	86° F.	85·5° F.	85° F.	85·5° F.
Colour in 2-ft. tube	Brown opaque	Brown opaque	Brown	Brown opaque	Brown
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon) ...	·35	·42	·35	·49	·35
Total Solids (grains per gallon)	3·8	4·7	3·7	4·0	3·4
Total Organic Solids (grains per gallon)	2·5	3·2	2·3	2·3	1·6
Free Ammonia (parts per million)	·052	·046	·042	·056	·036
Albuminoid Ammonia (parts per million)	·124	·120	·110	·132	·116
Nitrates as Ammonia (parts per million)	*Nil.*	·214	·278	*Nil.*	*Nil.*
Nitrites as Ammonia (parts per million)	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000)	·049	·057	*Nil.*	·066	·049

XI. SERIES.

4-8-06.

FOUR SAMPLES FROM MT. EMILY AND DISTRICT.

Samples.	Mt. Emily Reservoir.	Tap in house, 20-17 Armenian Street.	Standpipe in Selegu Road near Municipal Water Supply Office.	Standpipe, Thompson Road, dead end.
Temperature at time of taking samples ...	86° F.	84·3° F.	85·4° F.	87·5° F.
Colour in 2 ft. tube	Brown	Brown	Brown	Brown
Smell	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·42	·35	·35	·49
Total Solids do.	2·9	3·0	4·0	2·8
Total Organic Solids do.	1·1	2·0	1·9	1·6
Free Ammonia (parts per million) ...	·050	·020	·042	·008
Albuminoid Ammonia do. ...	·146	·126	·098	·106
Nitrates as Ammonia do. ...	*Nil.*	·140	·058	·112
Nitrites as Ammonia do. ...	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·052	·041	·049	·025

XII. SERIES.

4-8-06.

FOUR SAMPLES FROM PEARL'S HILL RESERVOIR AND DISTRICT.

Samples.	Pearl's Hill Reservoir.	Tap in Raffles Square.	Tap in house, 84, Teluk Ayer Street.	Tap in house, 4, Peckseale Street (in place of hydrant in Wallich Street.
Temperature at time of taking samples ...	87° F.	80·8° F.	86·5° F.	87° F.
Colour in 2 ft. tube	Brown, slightly opaque.	Brown, slightly opaque.	Brown, slightly opaque.	Brown, slightly opaque.
Smell	*Nil*	*Nil.*	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·35	·42	·35	·35
Total Solids do.	3·9	3·8	3·3	3·0
Total Organic Solids (grains per gallon) ...	2·1	2·9	2·6	2·4
Free Ammonia (parts per million)	·042	·030	·016	·062
Albuminoid Ammonia do.	·120	·120	·170	·128
Nitrates as Ammonia do.	*Nil.*	·068	·028	·102
Nitrites as Ammonia do.	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) ...	·066	·049	·079	·082

XII. SERIES.

15-8-06.

TWO EXTRA SAMPLES.

Samples.	Outlet from clear water tank.	Mt. Emily Reservoir, sample from filling pump.
Colour in 2-ft. tube	Brown	Brown
Smell	*Nil.*	*Nil.*
Chlorine (grains per gallon)	·42	·42
Total Solids (grains per gallon)	6·2	4·9
Total Organic Solids (grains per gallon) ...	2·6	2·4
Free Ammonia (parts per million)	·030	·024
Albuminoid Ammonia (parts per million) ...	·076	·104
Nitrates as Ammonia (parts per million) ...	*Nil.*	*Nil.*
Nitrites as Ammonia (parts per million) ...	*Nil.*	*Nil.*
Oxygen consumed (parts per 100,000) . .	·070	·070

FRANKLAND DENT,

Government Analyst and Science Lecturer, Inspector under Petroleum Ordinance, Straits Settlements.

(*b*) BACTERIOLOGICAL EXAMINATION OF WATER.

July 11th.

	1. Main Feeder No. I. above Bridge.	2. Main Feeder No. I. below Bridge.	3. Sub-feeder of No. II. above Workmen.	4. Sub-feeder of No. II. below Workmen.	5. Feeder from Kallang.	6. Rice Pond.	7. Reservoir Outlet.
Colonies on Agar, 3 days	180	180	240	1,400	425	320	88
Gelatine ...	320	675	350	4,500	800	440	120
McConkey's medium	Gas and acid in 48 hours with ·05 c.c.	Gas and acid in 24 hours with ·05 c.c.	Gas and acid in 24 hours with ·05 c.c.	Similar medium bleached.	Gas and acid in 24 hours with ·05 c.c.	Similar	Slight gas and acid with ·25 c.c. in 48 hours, medium unchanged with ·05 c.c.

In each case an organism of the Coli group was isolated from McConkey's broth by plating on Conradi's medium. The power of coagulating milk, however, was very weak.

No *B. Typhosus*, &c.

July 16th.

——	1 Unfiltered Water on No. 6.	2 No. 2 Filtered Well, 2nd day.	3 No. 3 Filtered Well, 3rd day.	4 No. 6 Filtered Well, 2nd day.	5 No. 7 Filtered Well, 1st day.	6 No. 8 Filtered Well, 4th day.	7 No. 12 Filtered Well, 4th day.	8 Clear Water Tank.	9 Low Level Reservoir, No. 1.	10 No. 2.	11 High Level Reservoir.
Colonies on Agar	120	90	40	56	90	60	70	85	50	70	75
,, Gelatine ...	180	120	50	75	120	100	84	120	90	85	110
McConkey's medium 1 c.c. added.	Gas and acid in 24 hours.	Gas and acid in 24 hours.	Acid only in 48 hours.	Gas and acid in 24 hours.	Acid only in 48 hours.	Acid only in 48 hours.	Acid only in 48 hours.	Gas and acid in 24 hours.	Gas and acid in 24 hours.	Gas and acid in 24 hours.	Gas and acid in 24 hours.

No organism having distinctive B. Coli cultural characteristics is ..lated, though one or two organisms caused fermentation of glucose and lactose. No B. Prodigiosus seen.

July 31st.

FILTRATION EXPERIMENT.

——	No. II. Unfiltered Water.	2nd day Working Filtrate.	No. III. Unfiltered Water.	3rd day Working Filtrate.	No. VI. Unfiltered Water.	2nd day Working Filtrate.	No. VII. Unfiltered Water.	4th day. Working Filtrate.
Colonies on Agar per c.c. ...	60	22	25	24	24	15	72	36
,, Gelatine ,, ...	75	30	32	36	30	18	85	42
McConkey's medium ...	0·5 c.c. faintly acid in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. no change. 2 c.c. acid only in 48 hours.	·05 c.c. no change. ·5 c.c. gas and acid in 24 hours.	·5 c.c. gas and acid in 48 hours.	·05 c.c. no change. ·5 c.c. gas and acid in 24 hours.	·5 c.c. no change. 2 c.c. acid only in 48 hours.	·05 c.c. faintly acid in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. gas and acid in 24 hours.

——	No. VIII. Unfiltered Water.	3rd day Working Filtrate.	No. IX. Unfiltered Water.	4th day Working Filtrate.	No. XI. Unfiltered Water.	3rd day Working Filtrate.	No. XII. Unfiltered Water.	1st day Working Filtrate.
Colonies on Agar per c.c. ...	32	20	25	12	54	28	42	26
,, Gelatine ,, ...	40	25	42	14	70	40	70	32
McConkey's medium ...	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. no change. 2 c.c. acid only in 48 hours.	·05 c.c. acid only in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. no change. 2 c.c. gas and acid in 48 hours.	·05 c.c. acid only in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. acid only in 48 hours. 2 c.c. gas and acid in 24 hours.	·05 c.c. acid only in 48 hours. ·5 c.c. gas and acid in 24 hours.	·5 c.c. acid only in 48 hours. 2 c.c. gas and acid in 24 hours.

July 27th.

	Mount Emily Reservoir.	Standpipe, Selegu Road.	House, Armenian Street.	Dead end, 2½ mile, Thompson Road	Pearl's Hill Reservoir.	Standpipe, Raffles Place.	House, Teluk Ayer Street.	Dead end, Pek Seah Street.
Colonies on Agar per c.c. ..	65	124	120	75	260	86	90	1,400
,, Gelatine ,, ...	80	150	140	90	340	110	115	1,500
McConkey's medium ...	·05 c.c. no change. ·5 c.c. acid only in 48 hours.	·05 c.c. no change. ·5 c.c. gas and acid in 48 hours.	·05 c.c. no change. ·5 c.c. acid only in 48 hours.	·05 c.c. faintly acid. ·5 c.c. acid only in 48 hours.	·05 c.c. gas and acid in 24 hours.	·05 c.c. no change. ·5 c.c. gas and acid in 24 hours.	·05 c.c. acid only in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. gas and acid in 24 hours.

August 4th.

Colonies on Agar per c.c. ...	90	96	54	32	70	100	600	800
,, Gelatine ,, ...	110	120	72	48	88	124	725	1,100
McConkey's medium ...	·05 c.c. no change in 48 hours. ·25 c.c. gas and acid in 24 hours.	·05 c.c. no change in 48 hours. ·25 c.c. gas and acid in 24 hours.	·05 c.c. ·25 c.c. no change in 48 hours. ·5 c.c. gas and acid in 48 hours.	·05 c.c. ·5 c.c. no change in 48 hours.	·05 c.c. no change in 48 hours. ·25 c.c. gas and acid in 24 hours.	·05 c.c. gas and acid in 24 hours.	·05 c.c. gas and acid in 24 hours.	·05 c.c. gas and acid in 24 hours.

August 3rd.

	RESERVOIR.				Entrance to No. 2 Filter Bed.	Clear Water Tank.	Leaving Tank.	Low Level Reservoir.	Suction Well.
	Surface Water.	3 feet deep.	9 feet deep.	13–14 feet deep.					
Colonies on Agar per c.c	50	56	75	744	92	80	84	94	76
,, Gelatine ,,	64	76	88	920	110	96	104	125	92
McConkey's medium ...	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. acid only in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 48 hours.	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.	·05 c.c. no change. ·5 c.c. gas and acid in 24 hours.	·05 c.c. gas and acid in 24 hours.	·05 c.c. no change in 48 hours. ·5 c.c. gas and acid in 24 hours.

No colony of *B. Prodigiosus* seen.

G. A. FINLAYSON, M.B.,
Government Bacteriologist.

(*c*) MECHANICAL ANALYSES OF SANDS USED FOR FILTERS.

SANDS FROM FILTER BEDS.

No	Description.	Albuminoid ammonia. Pts. per million.	1. Above 4·2 mm. in diameter. Percentage.	2. Between 4·2 and 2 mm. in diameter. Percentage.	3. Between 2 and 1 mm. in diameter. Percentage.	4. Less than 1 mm. in diameter. Percentage.
1	1st	35·0	2·76	27·63	38·30	31·31
2	2nd 11″ of Filter No. 1	39·0	2·36	28·29	38·70	30·65
3	3rd	39·0	2·63	32·46	37·14	27·77
4	1st	38·0	2·52	22·62	40·21	34·66
5	2nd 11″ of Filter No. 2	43·0	2·09	23·09	41·45	33·39
6	3rd	30·0	1·09	21·73	42·64	35·76
7	1st	53·0	2·1	21·1	34·85	42·55
8	2nd 10″ of Filter No. 3	57·0	1.48	17·77	32·30	48·46
9	3rd	35·0	2·0	14·53	31·23	52·83
10	1st	30·0	2·63	17·66	36·81	42·89
11	2nd ? Filter No. 4	30·0	3·26	26·73	39·40	30·61
12	3rd	2·5	Granite chips from the filter.			
13	1st	18·0	·79	7·30	28·95	62·93
14	2nd 7″ of Filter No. 5	15·0	1·25	8·28	30·12	60·35
15	3rd	12·0	·88	7·85	31·40	59·87
16	1st	23·0	2·39	14·76	38·04	44·78
17	2nd 8″ of Filter No. 6	20·0	1.46	13·66	36·28	48·62
18	3rd	8·0	1·59	14·68	36·11	47·62
19	1st	28·0	1·00	9·50	32·66	57·16
20	2nd 5″ of Filter No. 7	32·0	1·15	11·54	36·83	50·18
21	3rd	19·0	3·37	30·34	34·99	31·30
22	1st	24·0	1·45	25·45	39·72	33·36
23	2nd 8″ of Filter No. 8	26·0	1·41	25·20	38·21	35·16
24	3rd	17·0	1·40	27·55	39·77	31·31
25	1st	33·0	·94	22.20	40·99	35·86
26	2nd 6″ of Filter No. 8 on side ...	26·0	1·49	22·62	39·03	36·84
27	3rd	13·0	1·71	24·44	41·14	32·69
28	1st	30·0	3·87	25·75	40·25	32·00
29	2nd 8″ of Filter No. 9	24·0	2·75	27·50	39·06	30·75
30	3rd	15·0	2·75	28·80	34·50	36·00
31	1st	28·0	4·65	24·26	38·58	32·52
32	2nd 6″ of Filter No. 10	26·0	2·8	27·68	37·50	33·42
33	3rd	26·0	2·29	26·79	37·50	33·42
34	1st	18·0	3·20	23·20	34·80	38·80
35	2nd 8″ of Filter No. 11	18·0	1·58	21·21	37·34	39·87
36	3rd	15·0	3·35	25·67	36·58	34·40
37	1st	24·0	1·59	14·91	36·90	46.60
38	2nd 8″ of Filter No. 12	24·0	2·20	17·34	36·23	44·25
39	3rd	22·0	1·77	18·48	36·97	42·79
40	Mud from drain of Filter No 4	490·0	—	—	—	—
41	Scrapings from surface of Filter No. 5 ...	760·0	3·47	35·69	46·71	14·13
42	,, ,, ,, Filter No. 11 ...	24·6	2·31	37·14	38·12	22·41
43	New white sand, washed	2·0	2·69	13·81	34·53	48·96
44	,, ,, ,, unwashed	18·0	·36	8·43	22·21	69·00
45	Washed heap (2 coarse and 1 fine)	9·0	3·71	15·80	34·77	45·70
46	Reservoir sand, unwashed	68·0	2·50	23·16	37·82	36·50
47	Coarse Serangoon sand, unwashed	15·0	2·04	22·86	44·17	30·92
48	Fine Gaylang sand	29·0	·60	5·60	19·55	74·24
49	Scrapings of pipes	164·0	from House No. 22 Mohamed Alwee Lane.			
50	Do.	290·0	,, ,, ,, 46 South Bridge Road.			
51	Do.	106·0	,, ,, ,, 14 Prinsep Street.			
52	Do.	44·0	,, dark room of laboratory.			
53	Do.	85·0	,, school ,, ,,			

FRANKLAND DENT,

Government Analyst and Science Lecturer,

Inspector under Petroleum Ordinance Straits Settlements.

SINGAPORE, *3rd September*, 1906.

METROPOLITAN WATER BOARD.

WESTERN DISTRICT.

Telephone: 55 Westminster.

H. F. Rutter, M.Inst.C.E.,

Engineer.

Engineer's Office,

Commercial Road,

Pimlico, S.W.

21st February, 1907.

Dr. W. J. Simpson,

13, Queen Anne Street,

Cavendish Square, W.

Dear Sir,

I have pleasure in sending you herewith the result of our analysis of the sands you sent from Singapore.

The results are quite sufficient to condemn practically all the samples except that one marked "Fine Gaylang Sand (48)." This is the one which approximates most nearly in its composition that from which we obtain good results in practice.

Yours faithfully,

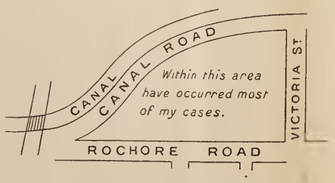
H. F. RUTTER.

MECHANICAL ANALYSIS OF SAND SAMPLES.

FILTERS AT SINGAPORE.

No.	Whence obtained.	Parts by weight left upon screens.									Remainder (Very fine).	Not Weighed.	Total parts.
		Length of side of square apertures in inches.											
		·080	·069	·061	·050	·040	·030	·020	·0099	·0052			
1	Unwashed Reservoir Sand (46) ...	17·240	1·660	6·820	8·159	7·190	17·590	15·392	17·062	5·117	3·390	·380	100·000
2	Coarse Serangoon Sand (47) ...	22·015	1·930	7·172	10·545	9·340	22·204	14·752	7·860	1·734	2·055	·393	100·000
3	Fine Gaylang Sand (48)	4·537	·355	1·625	2·690	2·730	8·715	12·545	46·640	18·340	1·632	·191	100·000
4	Coarse and Fine Sand, Mixed and washed (45)	11·715	1·150	3·520	5·710	5·520	17·690	17·980	27·760	7·672	·759	·524	100·000
5	Filter No. 3 (8)	14·585	2·470	5·250	7·510	6·422	15·960	16·860	24·680	5·810	·440	·013	100·000
6	Filter No. 7 (20)	9·207	1·430	3·485	4·710	5·735	17·602	19·137	31·507	6·607	·319	·261	100·000
7	Filter No. 11 (29)	22·069	1·617	7·834	7·900	6·015	14·700	13·075	20·109	6·049	·535	·097	100·000
8	New White Sand, Washed (43) ...	12·510	·887	4·910	5·304	5·995	16·352	17·165	25·667	9·290	1·752	·168	100·000

PREVALENCE OF MALARIA.

NAME.	(*a*) "What localities in Singapore Town have you observed to be most persistently malarious as indicated by attendance on patients?"	(*b*) "Have you noticed any particular causes in any or all of these localities to which you would assign the prevalence and persistence of malaria? If so, kindly state them."	(*c*.) "What localities within Singapore Island, but outside the Town, have you observed to be noticeably malarious?"	(*d*) "What variety or type of malaria have you found most common in your practice? If you have any records could you give percentages or approximate estimates?"	(*e*) "In your practice do you find malaria frequent among children of the different races: European, Chinese, Malay, Indian, Eurasian and others, and if so, which of these seem to suffer the most?"
Dr. Galloway	1. Newton, Gilstead Hill, Said Allee Road. 2. Srah Street, Wallich Street, Fras Street (Mt. Wallich Excavation). 3. Ohin Swee Road and its side streets. Formerly Neil Road and all the Telak Ayer district were notorious; now scarcely, if at all malarious.	As to *One*. "Borrow" pits left after railway construction, extensive excavations left from sand pits, and now full of water. As to *Two*. These streets are built on part of, and adjoining a wide area where a hill has been cut away, leaving a hard, impervious surface, full of pools of water. As to *Three*. Same reason as No. 2.	1. The Kallang Tunnel works and district. 2. The Western Side of Bukit Timah. My knowledge of "country" localities is small.	Benign Tertian, often a duplicate infection. See Dr. Kirk's article, "Journal of Malaya Branch of B.M.A." New series, vol. 1, 1904. Also a short article of mine in same volume.	It is difficult to give a definite answer. European children suffer frequently and severely. I think almost more so, as to severity, than any other race. But it is very common in all children, whatever race you mention. No.
Dr. Murray Robertson	Kallang.—Amongst the coolies employed at saw mills there. Kim Seng Bridge.—Amongst the coolies in the saw mills there, and in Chinese shop houses further up the river—at Mount Zion.	There is a river at each locality.		Benign Tertian at Pulo Brani. Quotidian at Kallang and Kim Seag Bridge.	(*e*) At Pulo Brani I have seen many cases amongst the Javanese coolies, and from Bukit Panjang I have seen two bad cases.
Dr. N. A. D. Hawes, R.A.M.C.	None.	None.	The island of Pulo Brani appears to me to be noticeably malarious. See return for malarial fever for 1905 and January to July 1906, at Pulo Brani, which will be sent hereafter.	Benign Tertian, have no records.	Do not find malaria much more frequent among children than adults; no marked partiality for any race.
Dr. E. W. Johnstone...	So far as my experience goes no part of Singapore Town has been proved to me as persistently or specially malarious. The proportion of cases of this nature coming under my observation, would lead me to the opposite conclusion.	The worst cases I have treated in Singapore of malarial fever, occurred respectively in Telak Ayer District, Telak Kuraw, and Raffles' Hotel, the last of which was undoubtedly imported, and this last description applies, I should say, to all cases in Europeans treated by me.	None, in my experience, specially so (which refers to the districts immediately surrounding the town itself), although of course evidence in a less pronounced degree than other tropical stations.	Bilious remittent fever has chiefly been presented to me for treatment in Singapore as elsewhere, and in my experience is most likely to come under the practitioner's treatment in private practice, although this does not apply in Hospital experience. Statistics not available.	In the Kampong malaria is of frequent occurrence in children of all ages in my experience, and in the following order of frequency as to nationality:— In the Kampong. 1. Malay. 2. Chinese. 3. Tamil. 4. Others (if any) In a town (as Singapore). 1. Eurasian. 2. Malay. 3. Tamil. 4. Chinese. 5. Other Indians. 6. Europeans (not frequent in my experience).
Dr. B. F. West	Canal Road, Victoria Street, and Rochore Road, a triangle thus:—  	Insanitary coolie houses. swampy places, bad drainage.	Not much experience. Gaylang, that portion round about the place where there is a vermicelli manufactory. Have had a number of cases there.	Tertian, no records.	My practice is almost entirely among the poor class of Chinese. Quite frequently have malarial cases among Chinese children. Fairly frequent among European children.
Major Martin, R.A.M.C.	I only attend the military on the islands of Blakan Mati and Pulo Brani. Malarial fevers are prevalent on both of these Islands.	Yes.—The localities are favourable for the existence of mosquitos.— There is an abundance of rank vegetation, and some pools of water. Also numerous extensive tidal mangrove swamps, open wells, cisterns, fire water tanks, and Dhobi tanks, on both Blakan Mati and Pulan Brani. * By Pulan Brani there are two large Malay Kampangs (pile villages) situated in tidal swamps, the inhabitants of which suffer from malarial fever.	Vide (*a*).	Ague and remittent fever. From January to June, 1906 (six months), I have observed about 75 cases, of which 84 per cent. have been ague and 16 per cent. remittent fever.	Among Chinese and Eurasians; simply because my practice lies chiefly among these. I have an impression to the effect that Eurasian children suffer more than do Chinese children, but as I have no figures I attach little weight to this impression.
Dr. de Tunzelmann	Most of my cases have and do come from Malay, Malaku, Bugis, Azlam, Fraser, Tan Quel Lan, Sago, Tringganu, Upper Hokim Streets and Sago Lane; but this is due to the fact that we (I and my two colleagues) are usually the medical men called in by the Chinese brothel keepers who live in these districts.	No.	I have no personal observations.	Tertian. The infection is very commonly multiple, producing a quotidian fever.	

PREVALENCE OF MALARIA—*continued.*

NAME.	(*a*) "What localities in Singapore Town have you observed to be most persistently malarious as indicated by attendance on patients?"	(*b*) "Have you noticed any particular causes in any or all of these localities to which you would assign the prevalence and persistence of malaria? If so kindly state them."	(*c*) "What localities within Singapore Island, but outside the Town, have you observed to be noticeably malarious?"	(*d*) "What variety or type of malaria have you found most common in your practice? If you have any records could you give percentages or approximate estimates?"	(*e*) "In your practice do you find malaria frequent among children of the different races, European, Chinese, Malay, Indian, Eurasian and others, and if so, which of these seem to suffer the most?"
Dr. E. De Vos...	Institution Hill (Europeans). The streets around the New Market (Chinese). Besides, I often treat Malay office-boys who live, I believe, in the Rochore District. At times I found malaria prevailing on other hills of the Tanglin District, for instance, Mt. Elizabeth, St Thomas' Walk, (where I live) and had malarial fever myself.	In these latter cases I assigned the prevalence of malarial fever to the fact that new roads were being built, as well as houses, close by. The persistence of malaria on Institution Hill I assign to the swampy vegetable gardens at the foot of that hill, which must certainly be very favourable to mosquito breeding.	No Experience.	The tertian type and most of the quotidian cases I take to be double tertians. Other types were almost always imported.	Comparatively often among European children; I have also treated cases where Malay and Chinese were concerned, but cannot form any opinion as to frequency.
Dr. Sam Teck...	Cecil Street, Beach Road, Hong Lim Market.	Insanitary, filthy surroundings.	None.	Some with fever once in two days. Some with fever once in three days.	My practice is confined to Chinese and Baboo. I have never had a case of malaria fever in young children.
Captain J. Kirkwood	Am situated at Alexandra Barracks.	* See above.	This place (Alexandra Barracks) is not noticeably malarious. "Anopheles larvæ found in large numbers in numerous situations, the chief sources are the numerous irrigated fields in the neighbourhood, numerous surface wells, and disused clay pits filled with water. The rainfall is very heavy, and surface of ground very irregular, favouring its collection into pools." "Anopheles Rossie most prevalent. Anopheles Sinensis also found, but not common."	For 1905, total number of admissions for malarial fever was 142, among an average annual strength of 682 troops. Of these the blood was not examined in 13 cases. In 7 cases parasites not found. In 54 cases benign tertians were found. In 66 cases tropical tertians were found. In 2 cases quartan parasites were found.	We have no children in the regiment stationed here. The men are natives of India. Probably a great number (53) of the cases of malaria were contracted in India, the regiment having only arrived here on the 10th January, 1905. The marked decrease this year would bear out this statement. As for the half-year ending June, 1906, only 20 cases were admitted. Admissions with malarial fever among an average general strength of 682 troops:— 1905. January ... 10 February ... 10 } 42 March ... 22 April... ... 17 May ... ... 13 } 40 June ... ... 10 July ... ... 11 August ... 6 } 26 September ... 9 October ... 8 November ... 20 } 34 December ... 6 Total ... 142 82 = 58 per cent. of total admissions with malarial fever. 60 = 42 per cent. of total admissions with malarial fever.
Dr. N. V. Samy	I am of opinion that there is hardly any place in town which is non-malarious, but in congested localities and in over-crowded houses and amongst the lower classes of people who are unclean in habits, its prevalence is noticeably persistent.	Almost all the cases of malarial fevers that are coming under my care are from such localities, and the races more prone to it are the Chinese and the Indian coolie-classes. I often hear people from such localities say that they are almost free from mosquito molestation, and that the chief intruders being the fetid house-bugs, which are to be found in enormous numbers there. Malarial fever appears to be endemic, as it were, in such places, attacking persons one after another as if the bugs themselves were the inoculators.	With regard to localities outside the town, all that portion of Bukit Timah beyond the eighth mile post appears to be persistently malarious.	I believe that the malarial fevers in the colony are commonly benign in type, having little or no tendency to assume that depraved condition of the system known as "Malarial Cachexia." The place is by no means free from the pernicious variety, but they are not of common occurrence.	Children are no exception, but those under one year of age seem to be less liable. It attacks all races of children indiscriminately, its proclivities being towards the lower classes of Indians, Malays, and Chinese in repleted districts.
Major J. Ritchie, R.A.M.C.	I have no patients in Singapore Town.	I have no patients in Singapore Town.	Along the Railway for some miles south of Bukit Panjang Station.	Benign Tertian.—I have kept no statistics, but I am under the impression that, as regards Tanglin Barracks, less than 5 per cent. of my cases have shown the malignant parasite present in the blood. In cases coming from Bukit Panjang, however, I should say the proportion is as high as 30 per cent.	The few European children under my charge have suffered very little from malaria, I have only had one case in three years, in an average strength of 21. Seasonal prevalence of malarial fever among the European Troops at Tanglin Barracks, Singapore, during the year 1905. Average annual strength of troops, 940. Month — Admissions into Hospital. January ... 14 February ... 4 } 55 March ... 37 April... ... 17 May ... ... 13 } 39 June ... ... 9 July ... ... 7 August ... 4 } 15 September ... 4 October ... 12 November ... 9 } 22 December ... 1 Total ... 131 94 = 72 per cent. of total admissions with malarial fever. 37 = 28 per cent. of total admissions with malarial fever. Note.—Compare this return with that for Alexandra Barracks, two miles distant from Tanglin Barracks.

APPENDIX C.

PARTICULARS OF CONSTRUCTION AND WORKING OF THE FILTER BEDS, BUKIT TIMAH ROAD, ASKED FOR BY PROFESSOR SIMPSON.

August, 1906.

The subjects for information and the relative particulars are as follow :—

1. (*a*) "Sources of sand, and average size of grains from each source?"

There are three kinds of sand used in the formation of the filter beds, viz. :—

"Reservoir," "Gaylang," and "Seranggoon."

The first is a coarse sand, the second a fine sand, and the third consists of coarse and fine sand grains naturally mixed. Particulars in detail of each sand will be found in the table attached.

Samples of the sand (washed and unwashed) have been forwarded.

(b) "Is there any difficulty in getting suitable sand?"

There is plenty of suitable sand available at present.

(c) "Is sea sand used?"

Sea sand is not used—it has been tried and found unsuitable owing to decomposition of Shell Fish.

2. "General description of construction of Filters?"

Each Filter consists of a rectangular tank with an inlet well on one wall and an outlet well on the opposite wall, the connection between the inlet well and the sand area being by means of a weir at about top sand level, and that between the bed and the outlet well by means of an orifice or orifices in the wall of the well at floor level of Filter. In the case of Filters 1–3, the inlet well is replaced by an inlet channel running along the centre of the bed throughout its length. Each outlet well is provided with an apparatus (in some cases automatic and in others hand regulated), for drawing off the filtered water at any desired rate. In the case of Filters 1–4 the under drainage consists of two courses of bricks laid flat over the whole area, the lower course consisting of parallel lines of single bricks laid $4\frac{1}{2}$ inches apart to form a channel for the water, all being laid transversely to fall to a central channel and covered with another layer of bricks laid close. In the case of Filter No. 5 the bed of the Filter forms the roof of a Clear water Tank below, the roof consisting of a series of arches carried on brick walls, the five spandrils being used to drain the bed of the Filter to the well at the lower end. In Filters 6, 7, and 8 the floor is formed to fall each way, transversely, towards the centre, and the floor at the centre has a gradient longitudinally from the upper to the outlet well end. In Filters 9–12 the floor is formed to fall continuously from the inlet well side towards the outlet side.

In the latter Filters Nos. 5–12 the lowest layer of the filtering medium is block granite (10 inches to 4 inches gauge) which serves for underdrainage.

The filtering medium consists, in order, from the bottom of layers of broken granite of diminishing gauge and mixed sand in the proportion of three of coarse to one of fine in one layer. The information tables, and sketches following explain the above more fully.

2. (*a*) "Number and size of Filters?"

The existing Filters are 12 in number, the sizes are given in the table, the total area being 149,922 square feet = 16,658 square yards = 3·44 acres.

(*b*) "Thickness of different layers, *i.e.*, thickness of layers of fine sand, of coarse sand, of fine granite or gravel and of coarse granite?"

These are given in the table and sketches following and attached.

(*c*) "Average size of grains of fine and of coarse sand, and average size of fine and of coarse gravel?"

The sizes of grains of the different kinds of sand are given in answer to query No. 1 (above), and of the various gauges of granite in the tables following, from which it will be seen that the granite consists of block granite (blocks from about 10 inches to 4 inches gauge) and broken granite varying from $2\frac{1}{2}$ inches to $\frac{1}{4}$ inch gauge.

3. "Are the sands from the different sources mixed or are they kept separate for the different layers?"

Formerly the sand was laid down in two layers, the lower layer of coarse (Reservoir) sand forming 50 to 75 per cent. of the total thickness, and the upper layer of fine (Gaylang) sand, 50 to 25 per cent. of the total thickness.

At the present time the sand is mixed in the proportion of three parts of coarse (Reservoir) sand to one part of fine (Gaylang) sand.

Until recently one bed has been working satisfactorily with Seranggoon sand only, but when recently renewed Reservoir sand was added and intermixed.

Generally the Seranggoon sand is considered more suitable.

4. "Depth of Water on Filters?"

In Filters 1–4, about 4 feet.
In remainder ,, 2 ,,

5. "Rate of filtration in gallons per acre daily?"

This varies at different times of the year.

The best time is at about February and March, after the rains, and the worst at about September, October, and November, after a dry spell of weather.

The nett rates of working vary as above, from an average of 280 gallons per square yard per day = 1,355,200 gallons per acre per day, to an average of 180 gallons per square yard per day = 871,200 gallons per acre per day, which, when inclusive of stoppages, aeration, cleaning, scraping and repairs, works out as follows:—from 215 gallons per square yard per day = 1,040,600 gallons per acre per day, to 138 gallons per square yard per day = 667,920 gallons per acre per day.

See table attached of inclusive rate of filtration per mensem and per annum.

6. "Method of regulating rate of filtration?"

In seven of the older filters the rate of filtration is regulated by telescopic weir outlet pipes adjusted by hand, and in the others by automatic floating pipes, with draw off orifices submerged at fixed depths.

7. "Method of regulating loss of head?"

Gauge plates are fixed to walls of filters and outlet wells by means of which the head on the filter is determined. The outlet apparatuses and arrangements, referred to above in No. 6, provide for any variation in the head, so that the rate of filtration is kept constant.

8. "Maximum limit of loss of head before aeration found necessary?"

The maximum head required is never allowed to exceed 2 feet, and this is seldom reached.

9. "Frequency of aeration?"

See tabular statement attached.

10. "Duration of aeration?"

The usual time allowed for aeration is twenty-four hours, but occasionally as much as forty-eight is allowed.

Including the time required for emptying and refilling, this means that each filter is out of work from two to three days when stopped for aeration.

11. "If aeration is not carried out, what happens to filters and water?"

The filtered water turns green in colour, and gives off a smell like sulphuretted hydrogen. A stringy weed grows in the filtered water where exposed to the sun.

The bed rapidly becomes choked.

The Health Officer's department have sent me the following reply as to the analytical result. "After four days the albuminoid ammonia increases as a rule beyond the admissible limit (·05 per million). Occasionally, however, this does not occur in seven days. In a few cases free ammonia appears in the filtered water though absent from the unfiltered. Chlorides are unaltered, and I have never found even a trace of nitrites and nitrates."

12. "Quantity of water filtered between aerations in gallons per acre?"

See tabular statement attached.

13. "Frequency of scraping?"

See tabular statement attached.

14. "Quantity of water filtered between scrapings in gallons per acre?"

See tabular statement attached.

15. "Average thickness or depth of sand removed at each scraping?"

About $\frac{1}{2}$ inch.

16. "Limit of reduction in thickness of sand layer by scraping before renewal of sand?"

The minimum thickness of sand permitted before renewal of the sand layer is 12 inches, but this is rarely reached, and in filters 1–3 it is never approached.

17. "What is done with the sand that is scraped off the filter? Is it washed and used afresh?"

It is occasionally rewashed, but generally disposed of for filling in trenches and similar purposes.

18. "Frequency of renewal of sand, also thickness of renewed sand laid down?"

The frequency of renewal varies considerably, say, roughly, once in two years.

The thickness of renewed sand depends on the thickness still left in the filter, and is made sufficient to bring the total thickness up to 24 inches in the newer filters and in the older beds to approach a maximum of 37 inches.

19. "Is new washed sand used for renewal or is old washed sand used?"

New washed sand is used for renewal.

20. "What is the method adopted in renewing the sand?"

The surface of the filter bed is first scraped to a thickness of 1 inch or $1\frac{1}{2}$ inches to remove the upper layer, then new sand, coarse and fine in the required proportion, is spread over the surface, and the whole of the sand is then turned over and well mixed, the new with the old, and aerated, after which it is levelled for use.

21. "Is the fresh sand mixed with the remaining layer of scraped sand underneath, or is the remaining layer taken up and washed and relaid with the additional new sand?"

It is mixed with the remaining layer, and *see* also No. 20.

22. "How frequently is the coarse sand taken up, and washed or renewed?"

It is difficult to say, as it is not found necessary to remove the lower layers of sand unless for extraordinary reasons, such as structural repairs to a filter.

23. "How frequently is the whole filter taken up, *i.e*, all the sand and granite and the filter washed or renewed?"

It is rarely found necessary to do this.

The following filters have been taken out in recent years :—

Years.	No. of Filter.	Reason for taking out.
1900 ...	Nos. 7 and 8	Repairs to Floors
1901 ...	... ...	... ...
1902 ...	... ...	... ...
1903 ...	No. 4	Cleansing
1904 }	No. 6	Repairs to Floor
1905 }		

24. "Is the new sand, both coarse and fine, and also the granite always washed before being laid down or renewed in the filter ?"

Yes, the whole of the materials for the beds are always washed before being laid down.

25. "What is done with the dirty sand that cannot be washed, if any ? Is it sold ?"

See No. 17. It is sometimes sold for road-making and similar purposes. It is chiefly used for filling on the Race Course.

26. "What is the method of washing the sand ?"

The sand is placed in hoppers, and stirred about with wooden paddles while clean water under pressure enters at the bottom of the hopper and passes up through the sand carrying the impurities with it.

The dirty water and washings overflow from the hopper into an open drain beneath. This is continued until the overflowing water runs clear, when the sand is clean.

27. "Percentage of filtered and unfiltered water consumed ?"

See tabular statement attached.

28. "Thickness of sand at start and stop ?"

In filters 1 to 3 the maximum thickness of sand at starting is 37 inches, and in the remainder 24 inches.

At stopping for renewal the minimum allowable is 12 inches, and the minimum thickness that is usually worked to is 15 inches. *See* also No. 16.

29. "Average rate of filtration per annum and per mensem ?"

See tabular statement attached.

N.B.—The calculations in the Tables are believed to be accurate, but they have only been checked once, by a Draftsman.

R. PEIRCE,

12–12–06.

Size of Sieve.	Meshes, per sq. in.	RESERVOIR SAND.		GAYLANG SAND.		SERANGGOON SAND.	
		Source.	Colour.	Source.	Colour.	Source.	Colour.
		The beds of Streams feeding the Impounding Reservoir.	Brown.	Low lying land about 1 mile from the sea near Gaylang.	White.	Pits adjoining the Kallang River.	White.
		Percentage retained.	Percentage passed.	Percentage retained.	Percentage passed.	Percentage retained.	Percentage passed.
12″ × 12″	144	38 %	62 %	8 %	92 %	24 %	76 %
16″ × 16″	256	47 %	53 %	14 %	86 %	32 %	68 %
20″ × 20″	400	61 %	39 %	25 %	75 %	48 %	52 %
30″ × 30″	900	75 %	25 %	42 %	58 %	67 %	33 %
38″ × 38″	1,444	83 %	17 %	59 %	41 %	80 %	20 %
50″ × 50″	2,500	95 %	5 %	87 %	13 %	93 %	7 %
60″ × 60″	3,600	97 %	3 %	89 %	11 %	93 %	7 %
76″ × 76″	5,776	98 %	2 %	94 %	6 %	96 %	4 %
90″ × 90″	8,100	99 %	1 %	98 %	2 %	97 %	3 %

AREA OF FILTERS AND THICKNESS AND COMPOSITION OF THE FILTERING MEDIUM.

AUGUST, 1906.

FILTER No. 1.

	Area of Filter in Yards.	Thickness and Composition of Sand Layer.		Thickness and Gauge of Granite Layers.	
Top ...	1,311	28½″	Mixed 3 of Reservoir to 1 of Gaylang	3″	¼″ gauge
				3″	½″ „
Bottom	...	...	...	3″	1″ „

On two courses of bricks to form false bottom for under drainage.

FILTER No. 2.

	Area of Filter in Yards.	Thickness and Composition of Sand Layer.		Thickness and Gauge of Granite Layers.	
Top ...	1,320	34″	Mixed 3 of Reservoir to 1 of Gaylang	3″	¼″ gauge
				3″	½″ „
Bottom	...	...	...	3″	1″ „

On two courses of bricks to form false bottom for under-drainage.

FILTER No. 3.

	Area of Filter in Yards.	Thickness and Composition of Sand Layer.		Thickness and Gauge of Granite Layers.	
Top ...	1,311	32″	Mixed 3 of Reservoir to 1 of Gaylang	3″	¼″ to ½″ gauge
				3″	½″ to ¾″ „
Bottom	...	...	...	3″	1″ gauge

On two courses of bricks to form false bottom for under-drainage.

FILTER No. 4.

	Area of Filter in Yards.	Thickness and Composition of Sand Layer.		Thickness and Gauge of Granite Layers.	
Top ...	1,195	21″	Mixed 3 of Reservoir to 1 of Gaylang	4″	½″ gauge
				4″	¾″ „
Bottom	...	...	...	4″	1½″ „

On two courses of bricks to form false bottom for under-drainage.

AREA OF FILTERS AND THICKNESS OF COMPOSITION OF THE FILTERING MEDIUM—*continued.*

AUGUST, 1906.

FILTER No. 5.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,612	19½″	Mixed 3 of Reservoir to 1 of Gaylang	3″	½″ to ¾″ gauge
				3″	1½″ gauge
Bottom	...	...	...	3″	2½″ ,,
Average thickness over crowns and spandrils of arches beneath, 17″ block granite.					

FILTER No. 6.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,444	23″	Mixed 3 of Reservoir to 1 of Gaylang	2″	¼″ to ½″ gauge
				7″	2½″ gauge
Bottom	...	...	...	9″	Block granite

FILTER No. 7.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,444	16½″	Mixed 3 of Reservoir to 1 of Gaylang	3″	½″ gauge
				3″	¾″ ,,
				3″	2¼″ ,,
Bottom	...	...	...	9″	Block granite

FILTER No. 8.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,520	18½″	Mixed 3 of Reservoir to 1 of Gaylang	4″	⅛″ to ¾″ gauge
				4″	1½″ gauge
				4″	2½″ ,,
Bottom	...	...	...	9″	Block granite

FILTER No. 9.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,372	20″	Mixed 3 of Reservoir to 1 of Gaylang	3″	½″ to ¾″ gauge
				3″	½″ to 2½″ ,,
Bottom	...	...	...	9″	Block granite

FILTER No. 10.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,374	19½″	Mixed 3 of Reservoir to 1 of Gaylang	2″	½″ gauge
				3″	1½″ to 2″ gauge
				3″	2½″ to 3″ ,,
Bottom	...	...	...	7″	Block granite

FILTER No. 11.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,381	23″	Mixed 3 of Reservoir to 1 of Gaylang	2″	¾″ gauge
				4″	2¼″ ,,
Bottom	...	...	...	9″	Block granite

FILTER No. 12.

	Area of Filter in Yards.	Thickness and Composition of Sand Layers.		Thickness and Gauge of Granite Layers.	
Top ...	1,374	22″	Mixed 1 of Reservoir to 2 of Seranggoon	2″	½″ to ¾″ gauge
				2″	1″ to 1½″ ,,
				2″	2¼″ gauge
Bottom	...	...	...	8″	Block granite

FILTER No. 1

Year 1904.	Days between Aerations.	Quantity Filtered between each Aeration.	Gallons per Acre per Aeration.	Days between Scrapings.	Quantity Filtered between each Scraping.	Gallons per Acre per Scraping.
January	9	2,382,524	2,972,441	22	4,887,772	18,102,859
February	33	7,866,000	29,133,333	33	7,866,000	29,133,333
March	13	3,146,400	11,653,333	28	6,555,000	24,277,777
April	8	3,277,500	12,144,444	...	...	...
May	4	2,884,200	10,682,222	...	...	...
June	9	588,639	2,180,129	...	...	...
July	8	1,494,540	5,535,333	93	7,050,558	26,113,177
August	7	1,835,400	6,797,777	...	...	...
September... ...	6	1,660,600	6,150,369	...	...	...
October	8	1,022,580	3,787,333	...	...	...
November... ...	10	1,782,960	6,603,555	...	...	...
December	9	3,390,537	12,557,544	133	27,989,850	103,666,111
Average	10	2,610,991	9,183,151	61	10,869,836	40,258,651

FILTER No. 2

January	13	3,021,480	11,190,666	...	...	...
February	12	3,039,300	11,256,666	29	6,078,600	22,513,333
March	14	3,300,000	12,222,222	16	3,960,000	14,666,666
April	13	3,045,900	11,288,518	...	...	...
May	14	1,801,800	6,673,333	70	12,911,400	47,820,000
June	12	1,597,640	5,919,185	...	...	...
July	9	775,500	2,872,222	62	6,386,160	23,652,444
August	10	422,400	1,564,444	...	...	...
September... ...	6	427,680	1,583,999	...	...	...
October	9	1,069,200	3,960,000	...	...	...
November... ...	8	1,529,600	3,813,333	...	...	...
December	10	3,344,000	12,385,185	...	...	...
Average	10	1,947,875	7,060,822	44	7,321,540	27,163,110

FILTER No. 3.

January	14	2,427,197	8,989,618	...	...	...
February	13	2,386,020	8,837,111	...	...	...
March	14	2,493,133	8,740,000	...	...	...
April	13	3,277,500	2,138,888	28	5,709,400	21,145,925
May	14	3,015,300	11,167,777	...	...	...
June	15	2,274,585	8,424,388	53	11,628,570	43,068,777
July	11	2,884,200	10,692,222	36	8,390,400	31,075,555
August	7	1,835,400	6,797,777	43	9,701,400	35,931,111
September ...	7	1,835,400	6,797,777	...	...	...
October	8	983,250	3,641,666	...	...	...
November... ...	9	2,017,903	7,473,714	80	12,402,060	45,933,555
December	7	2,665,700	9,872,962	38	3,146,400	11,653,333
Average	11	2,341,299	9,549,741	46	8,496,371	31,468,064

FILTER No. 4.

Year 1904.	Days between Aerations.	Quantity Filtered between each Aeration.	Gallons per Acre per Aeration.	Days between Scrapings.	Quantity Filtered between each Scraping.	Gallons per Acre per Scraping.
January	14	2,160,000	9,000,000	...	...	...
February	17	3,729,240	15,538,500	...	...	...
March	16	4,099,680	17,082,000	...	...	...
April	13	3,952,260	16,467,750	...	...	...
May	12	3,344,220	13,934,250	...	...	...
June	9	2,634,840	10,978,500	...	...	...
July	...	...	...	141	29,793,960	124,141,500
August	6	2,052,135	8,550,562	24	6,688,440	27,868,500
September ...	6	1,925,460	8,022,750	...	...	...
October	9	2,008,040	8,366,833	...	...	...
November... ...	8	1,984,040	8,266,833	101	22,880,860	95,336,916
December... ...	10	3,853,710	16,057,125	...	...	...
Average	10	2,885,784	12,024,784	88	19,787,753	82,448,992

FILTER No. 5.

January	9	2,996,208	9,079,418	...	...	...
February	13	4,191,200	12,700,621	...	...	...
March	13	4,191,200	12,700,621	...	...	...
April	13	4,030,000	12,212,121	...	...	...
May	12	3,224,000	9,769,696	69	20,311,200	61,459,090
June	12	3,975,600	12,047,772	...	...	...
July	9	3,009,066	9,118,381	85	23,535,200	71,318,787
August	6	2,015,000	6,106,062	...	...	...
September... ...	6	2,015,000	6,106,062	48	13,540,800	41,032,727
October	8	1,182,133	3,309,494	...	...	...
November	8	2,538,900	7,693,636	67	12,654,200	38,346,060
December	9	3,976,266	12,049,292	...	...	...
Average	9	3,278,720	9,407,723	67	17,512,850	53,061,666

FILTER No. 6.

January	9	2,691,616	9,282,767	...	...	...
February	19	3,776,060	13,020,896	33	7,230,108	24,931,406
March	13	1,345,808	4,640,717	...	...	...
April	12	2,587,840	8,923,551	...	...	...
May	14	3,321,200	11,452,413	...	...	...
June	11	3,176,800	10,954,482	...	...	...
July	10	2,888.000	9,958,620	153	28,081,468	96,832,648
August	8	2,502,233	6,830,804	...	...	...
September... ...	6	1,925,333	6,639,080	52	13,284,800	48,509,655
October	9	1,357,360	4,860,551	...	...	...
November	1	288,800	995,862	...	...	...
December	...	...	...	...	...	...
Average	10	2,361,058	7,959,976	79	16,198,792	56,757,903

FILTER No. 7.

Year 1904.	Days between Aerations.	Quantity Filtered between each Aeration.	Gallons per acre per Aeration.	Days between Scrapings.	Quantity Filtered between each Scraping.	Gallons per acre per Scraping.
January	10	2,888,000	9,958,620	...	...	...
February	16	4,658,344	16,063,254	...	...	...
March	14	3,898,800	13,444,137	...	...	...
April	13	3,610,000	12,448,275	...	...	...
May	12	2,984,266	10,290,572	71	18,194,400	62,739,310
June	10	2,984,266	10,290,572	...	...	...
July	10	2,454,800	8,464,826	61	14,728,800	50,788,965
August	7	2,021,600	6,971,041	...	...	...
September... ...	6	1,877,200	6,473,103	58	14,728,800	50,788,965
October	8	1,111,880	3,834,068	...	...	...
November... ...	9	2,382,600	8,215,861	81	13,876,840	47,851,160
December	6	2,490,900	8,589,309	...	...	...
Average	10	2,780,388	9,595,303	67	15,382,210	53,042,100

FILTER No. 8.

January	9	2,736,000	8,825,806	...	...	...
February	5	1,520,000	4,903,225	...	...	...
March	13	3,850,666	12,421,505	62	13,072,000	42,167,741
April	13	3,952,000	12,748,387	...	...	...
May	16	3,667,000	11,829,031	...	...	...
June	4	912,000	2,941,935	80	16,150,000	52,096,774
July	...	under	repairs.	...	...	...
August	...	...	...	...	...	...
September... ...	...	...	...	...	...	...
October	8	194,560	627,612	...	...	...
November... ...	11	1,386,240	4,471,741	...	...	...
December	15	5,086,000	15,922,580	...	...	...
Average	10	2,589,385	8,299,091	71	14,611,000	47,132,257

FILTER No. 9.

January	9	2,469,600	8,991,428	...	...	...
February	16	4,527,600	16,120,000	...	...	...
March	13	3,704,400	13,230,000	28	7,408,800	26,460,000
April	13	3,292 800	11,760,000	26	6,585,600	23,520,000
May	11	2,561,066	9,146,666	23	4,664,800	16,660,000
June	9	2,469,600	8,843,809	45	10,427,200	37,240,000
July	6	1,783,600	6,370,000	...	...	...
August	5	1,152,480	4,116,000	...	...	...
September... ...	5	2,469,600	6,174,000	...	...	...
October	6	2,873,280	10,261,714	54	18,110,400	64,680,000
November... ...	4	3,076,500	11,166,666	54	19,756,800	70,560,000
December	5	2,212,350	7,776,250	...	...	...
Average	8	2,716,073	9,495,544	38	21,037,333	39,853,333

FILTER No. 10.

Year 1904.	Days between Aera-tions.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	Days between Aera-tions.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	8	480,900	1,717,499	...	...	...
February	11	3,022,800	10,795,714	...	...	...
March	13	2,816,700	10,059,642	...	...	...
April	12	3,297,600	11,777,142	40	10,167,600	36,312,857
May	12	2,885,400	10,304,999	...	...	...
June	13	3,147,600	11,241,701	52	11,876,400	42,201,428
July	10	1,992,300	7,115,350	43	10,161,600	36,312,857
August	4	1,264,080	4,514,570	...	...	...
September... ...	5	1,374,000	4,907,142	...	...	...
October	5	1,082,025	3,864,374	80	16,900,200	60,357,857
November... ...	7	2,301,400	8,219,464	...	...	...
December... ...	4	1,534,300	5,479,642	54	9,755,400	34,840,714
Average	8	2,099,925	7,499,937	53	11,773,400	42,005,142

FILTER No. 11.

January	...	under	repairs.	...	...	...
February	...	...	...	...	...	...
March	...	...	...	...	...	...
April	...	...	...	...	...	...
May	...	...	...	...	...	...
June	...	...	...	...	...	...
July	7	483,350	1,726,250	...	...	...
August	6	397,037	1,417,990	...	...	...
September ...	7	1,452,383	5,178,749	...	...	...
October	6	1,249,900	4,438,928	...	...	...
November... ...	7	1,622,675	5,795,267	...	...	...
December... ...	6	3,210,825	11,467,231	...	...	...
Average	6	1,402,695	5,004,069	...	...	...

FILTER No. 12.

January	...	...	...	...	...	...
February	...	...	...	...	...	...
March	...	...	...	...	...	...
April	...	...	...	..	...	...
May	...	...	...	...	...	...
June	...	1,236,600	4,416,428	...	...	...
July	6	1,719,750	6,141,964	...	...	...
August	5	1,580,100	5,643,213	...	...	...
September ...	6	1,648,800	5,888,571	...	...	...
October	8	1,659 233	5,806,785	...	...	...
November... ...	7	3,847,200	13,740,000	...	...	...
December... ...	7	2,748,000	9,814,283	70	14,633,100	52,332,500
Average	16	2,064,240	7,350,177	70	14,633,100	52,332,500

AERATIONS AVERAGES FOR ALL THE FILTERS.

SCRAPING AVERAGES FOR ALL THE FILTERS.

Year 1904.	Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	Year 1904.	Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January ...	10	2,425,352	7,990,826	January ...	...	...	...
February ...	15	3,871,656	13,836,931	February ..	...	...	...
March ...	13	3,284,678	11,619,417	March ...	...	...	...
April ...	12	3,505,676	12,192,907	April ...	...	...	...
May ...	12	2,954,405	10,525,095	May ...	...	...	...
June ...	16	2,272,560	8,021,672	June ...	...	...	...
July ...	7	1,928,510	6,792,517	July ...	...	...	...
August ...	6	1,645,410	5,391,840	August ...	...	...	...
September ...	6	1,692,859	5,792,872	September...	...	...	...
October ...	7	1,316,120	4,729,946	October ...	...	...	...
November ...	7	2,063,234	7,204,661	November...	...	...	...
December ...	8	3,137,508	11,270,127	December ...	...	...	...
Average ...	9	2,508,164	8,780,725	Average ...	59	14,329,475	47,765,792

FILTER No. 1

Year 1905.	No. of Days between each Aeration.	Quantity Filtered between each Aeration.	Gallons per Acre per Aeration.	No. of Days between Scrapings.	Quantity Filtered between each Scraping.	Gallons per Acre per Scraping.
January	9	2,403,500	8,901,751	33	7,538,250	27,919,444
February	7	2,512,750	9,306,481	...	...	...
March	9	2,840,500	10,520,370	...	...	...
April	8	2,622,000	9,711,111	131	35,528,100	131,585,555
May	8	2,146,762	7,950,971	...	...	...
June	8	2,185,000	8,092,592	...	...	...
July	9	1,693,133	6,270,863	...	...	...
August	8	2,010,200	7,445,188	...	...	...
September... ...	7	1,884,562	6,979,860	102	23,335,800	86,428,888
October	7	2,010,200	7,778,517	18	3,867,450	14,323,888
November... ...	8	1,966,500	7,283,055	...	...	...
December	8	2,381,650	8,820,925	...	...	...
Average	8	2,221,396	8,255,149	71	17,567,400	65,064,444

FILTER No. 2

January	8	2,222,000	8,229,629	41	9,570,000	35,444,444
February	8	2,860,000	10,592,592	...	...	...
March	8	2,750,000	10,185,184	...	...	...
April	8	2,530,000	9,333,336	76	21,780,000	80,666,666
May	8	2,244,000	8,311,110	37	9,504,000	35,200,000
June	8	2,288,000	8,474,074	...	...	...
July	9	2,112,000	7,822,222	...	...	...
August	7	2,071,000	7,577,777	112	25,344,000	93,866,666
September... ...	7	1,936,000	7,170,370	...	...	...
October	8	2,112,000	7,822,222	54	12,144,000	44,977,777
November... ...	7	1,914,000	7,088,888	...	...	...
December	8	2,354,000	8,718,518	...	...	...
Average	8	2,282,750	8,443,827	64	15,668,400	58,031,111

FILTER No. 3.

Year 1905.	No. of Days between each Aeration.	Quantity filtered between each Aeration.	Gallons per Acre per Acration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per Acre per Scraping.
January	9	2,393,133	8,863,455	10	2,097,600	7,768,888
February	8	2,840,500	10,520,333	...	...	...
March	9	2,840,500	10,520,333	...	...	...
April	8	2,622,000	9,711,111	...	...	...
May	8	2,316,100	8,578,147	126	34,741,500	128,672,222
June	8	2,097,600	7,768,888	17	3,933,000	14,566,666
July	9	2,359,800	8,739,999	...	...	...
August	8	2,010,200	7,445,185	79	18,091,800	67,006,666
September... ...	7	1,966,500	7,283,333	34	7,603,800	28,162,222
October	10	2,010,200	7,445,185	...	...	...
November ...	8	1,966,500	7.283,333	54	11,799,000	43,700,000
December	11	2,392,575	8,861,388	...	...	...
Average	8	2,317,967	8,585,057	53	13,044,450	70,162,777

FILTER No. 4.

January	9	3,403,180	14,179,916	34	11,010,600	45,877,560
February	8	3,058,500	12,743,750	...	...	...
March	8	2,936,160	12,234,000	59	18,718,020	77,991,750
April	8	3,058,500	12,743,750	...	...	...
May	9	3,058,500	12,410,416	...	...	...
June	8	2,813,820	11,724,250	113	35,600,940	148,337,250
July	8	2,839,405	11,830,854	...	...	...
August	8	3,058,500	12,743,750	...	...	...
September ...	7	2,813,820	11,724,250	...	...	...
October	7	2,660,895	11,087,060	110	34,371,860	143,216,083
November ...	7	2,569,140	10,704,750	...	...	...
December	7	2,752,650	11,469,375	...	...	...
Average	7	2,751,920	10,474,676	79	24,925 355	103,855,660

FILTER No. 5.

January	8	2,767,266	8,384,989	39	14,508,000	43,963,636
February	7	2,418,000	7,327,272	...	...	...
March	7	3,035,933	9,199,797	59	15,636,400	47,383,030
April	8	3,324,750	10,074,999	...	...	...
May	8	2,632,933	7,978,583	...	...	...
June	7	2,498,600	7,321,514	...	...	...
July	8	2,579,200	7,815,757	...	...	...
August	7	2,337,400	7,083,030	163	50,536,200	153,140,000
September... ...	7	2,256,800	6,838,787	...	...	...
October	7	2,337,400	7,083,030	...	...	...
November ...	7	1,748,200	5,373,332	122	32,078,800	97,208,484
December	7	2,337,400	7,083,030	...	...	...
Average	7	2,522,823	7,630,343	95	28,189,850	85,423,787

FILTER No. 6.

Year 1905.	No. of Days between each Aeration.	Quantity filtered between each Aeration.	Gallons per Acre per Aeration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per Acre per Scraping.
January	...	...	...	...	...	...
February	...	...	...	...	...	...
March	...	...	...	...	...	...
April	...	...	...	...	...	...
May	...	...	...	...	...	...
June	...	...	...	...	...	...
July	...	...	...	...	...	...
August	...	...	...	...	...	...
September... ...	...	...	...	...	...	...
October	...	...	...	...	...	...
November ...	8	613,700	2,116,206	...	...	...
December	7	1,756,866	6,058,160	...	...	...
Average	7	1,185,283	4,087,183	...	...	...

FILTER No. 7.

January ...	...	8	2,502,933	8,630,804	58	17,472,400	60,249,655
February ...	...	7	2,372,868	8,182,240	38	9,891,400	34,108,275
March ...	...	8	2,888,000	9,958,620	...	...	...
April ...	...	8	2,767,666	9,543,677	...	...	...
May ...	...	8	2,527,000	8,713,542	...	...	...
June ...	...	7	2,214,133	7,634,942	98	28,807,800	99,337,241
July ...	...	7	2,214,133	7,634,942	...	...	...
August ...	...	7	2,238,200	7,717,905	...	...	...
September...	...	7	2,021,600	6,971,034	...	...	...
October ...	...	7	2,117,866	7,302,988	114	28,591,200	98,591,200
November ...		6	1,805,000	6,224,137	...	...	...
December ...	...	7	2,021,600	6,971,034	68	17,306,400	59,677,241
Average ...	...	7	2,307,582	7,957,155	75	20,413,840	70,392,551

FILTER No. 8.

January ...	...	12	3,648,000	11,767,741	...	...	...
February ...	...	9	3,166,666	10,215,354	...	...	...
March ...	...	8	3,166,666	10,215,354	...	...	...
April ...	...	8	3,135,000	10,112,878	...	...	...
May ...	...	8	2,558,666	8,253,763	...	...	...
June ...	...	8	2,214,133	7,142,365	...	...	...
July ...	...	7	3,268,000	10,051,537	...	...	...
August ...	...	7	2,584,000	8,335,483	332	84,515,060	272,629,255
September...	...	6	2,052,000	6,619,354	...	...	...
October ...	...	7	2,128,000	6,864,515	...	...	...
November ...		8	2,432,000	7,845,161	91	16,720,000	53,870,903
December ...	...	8	2,755,000	8,887,080	...	...	...
Average ...	...	8	2,759,010	8,859,215	211	50,617,530	163,250,079

FILTER No. 9.

Year 1905.	No. of Days between each Aeration.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	6	1,852,200	6,615,000	122	32,009,200	114,318,517
February	7	2,355,266	8,411,666	...	...	...
March	7	2,381,000	8,903,511	...	...	...
April	6	1,943,666	7,608,333	...	...	...
May	7	1,903,650	6,798,750	23	6,174,000	22,050,000
June	6	1,715,000	6,125,000	58	11,799,200	42,140,000
July	7	2,058,000	7,350,000	140	22,569,400	80,605,000
August	7	1,920,800	6,860,000	...	...	...
September... ...	4	1,262,240	4,508,000	...	...	...
October	5	1,372.000	4,900,000	...	...	...
November... ...	5	686,000	2,450,000	...	...	..
December	5	1,591,526	5,684,000	12	13,411,300	47,897,500
Average	6	1,753,445	6,351,188	71	17,192,620	61,402,214

FILTER No. 10.

January	7	2,146,875	7,667,410	113	29,884,500	106,730,357
February	8	2,862,500	10,223,213	...	...	...
March	8	2,737,833	8,587,499	...	...	...
April	6	2.232,750	7,974,107	...	...	...
May	7	1,481,933	5,292,618	40	9,242,400	33,008,571
June	6	1,846,500	6,594,642	108	17,037,600	60,848,571
July	6	1,854,900	6,624,642	...	...	...
August	5	1,854,900	6,624,642	...	...	...
September... ...	4	1,099,200	3,925,714	...	...	...
October	4	1,264,080	4,661,785	61	17,724,600	63,302,142
November... ...	4	1,007,600	3,598,570	...	...	...
December	5	1,566,360	5,594,142	22	9,878,400	35,244,285
Average	5	1,829,619	6,447,415	65	16,753,500	59,826,745

FILTER No. 11.

January	8	2,255,733	8,055,833	54	17,262,500	67,651,785
February	8	2,934,625	10,480,803	...	...	...
March	9	2,157,812	7,706,472	60	14,086,200	50,307,887
April	6	2,157,812	7,706,472	...	...	...
May	7	2,054,237	7,336,562	56	15,467,200	55,240,000
June	7	1,933,400	6,905,000	35	7,595,500	77,126,785
July	7	2,002,450	7,151,607	...	...	...
August	6	1,657,200	5,918,571	...	...	...
September ...	4	1,325,760	4,734,856	...	...	...
October	5	1,325,760	4,734,856	87	2,071,500	7,398,214
November... ...	6	1,049,560	3,764,645	72	13,810,000	49,321,428
December	6	1,657,000	5,918,571	37	9,667,000	34,525,000
Average	6	1,875,937	6,701,187	56	11,422,842	48,795,871

FILTER No. 12.

Year 1905.	No. of Days between each Aeration.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	7	2,112,525	7,794,731	45	11,129,400	39,747,857
February	8	2,862,500	10,223,214	...	...	...
March	6	2,318,625	8,280,803	...	...	...
April	6	1,975,125	6,979,017	...	...	...
May	6	1,872,075	6,685,987	112	31,876,800	113,845,714
June	6	1,854,900	6,374,642	...	...	...
July	7	1,914,000	6,835,714	30	6,870,000	24,535,714
August	5	1,428,960	5,103,428	...	...	...
September... ...	4	1,007,600	3,596,904	57	20,012,400	71,472,857
October	4	1,209,120	4,318,285	31	6,595,200	23,554,285
November... ...	...	...	...	...	...	...
December	6	1,525,140	5,446,921	65	8,656,200	30,915,000
Average	5	1,807,324	6,512,694	56	14,190,000	50,678,571

AERATIONS AVERAGES FOR ALL THE FILTERS.

Year 1905.	Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.
January ...	8	2,518,840	8,981,032
February ...	7	2,749,470	9,838,811
March ...	7	2,732,093	9.664,722
April ...	7	2,579,024	9,300,731
May ...	7	2,254,168	8,188,235
June ...	7	2,147,007	7,629,662
July ...	7	2,279,192	8,177,260
August ...	6	2,110,205	7,425,512
September ...	5	1,796,462	6,395,678
October ...	6	1,851,957	6,727,131
November ...	6	1,068,927	5,793,825
December ...	7	2,090,980	7,459,428
Averages for the year	6	2,181,527	7,956,835

SCRAPINGS AVERAGES FOR ALL THE FILTERS.

Year 1905.	Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January ...	...	...	...
February ...	...	...	...
March ...	...	...	...
April ...	...	...	...
May ...	...	...	...
June ...	...	. .	...
July ...	...	...	...
August ...	...	...	...
September...	...	...	...
October ...	...	...	...
November...	...	...	..
December ...	...	...	...
Averages for the year	74	20,907,798	76,080,346

FILTER No. 1.

Year 1906.	No. of Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	8	2,933,362	10,864,311	107	25,498,950	94,440,555
February	8	2,895,125	10,722,685	36	12,240,625	45,331,944
March	6	1,911,081	7,374,374	26	7,866,000	29,133,333
April	4	1,238,895	5,250,068	55	13,382,200	49,563,703
May	4	1,092,500	4,046,295	32	5,702,850	21,121,666
June	4	874,000	3,237,037	10	1,835,400	6,797,777
July	4	258,922	984,922	29	2,818,650	10,439,444
August	5	1,179,900	4,370,000	...	...	...
September ...	4	1,048,800	3,884,444	...	...	...
Average for January–Sept.	5	1,492,509	5,637,126	42	9,906,382	9,546,917

FILTER No. 2.

January	8	3,159,750	11,702,777	62	15,510,000	57,444,444
February	7	2,805,000	10,388,888	31	12,870,000	47,666,666
March	6	2,252,250	8,341,666	36	10,032,000	37,155,555
April	5	1,537,800	5,695,555	55	13,299,000	49,255,555
May	4	1,056,000	3,911,111	32	6,600,000	24,444,444
June	4	1,100,000	4,074,074	...	...	...
July	3	990,000	3,666,666	31	6,630,000	24,555,555
August	4	1,056,000	3,911,111	5	...	...
September ...	3	1,100,000	4,074,074	5	...	...
Average for January–Sept.	4	1,672,977	6,196,213	38	11,662,200	48,104,443

FILTER No. 3.

January	7	3,040,300	11,260,370	...	...	...
February	7	3,211,950	11,896,111	...	...	...
March	6	2,208,480	8,179,555	122	23 561,600	87,265,185
April	5	1,515,841	5,614,222	...	...	...
May	4	1,134,533	4,201,974	48	11,569,575	4,285,027
June	4	1,101,240	4,078,666	41	10,750,200	39,815,555
July	4	1,101,240	4,078,666	...	...	...
August	4	1,179,900	4,370,000	...	...	...
September... ...	3	971,933	3,599,230	94	19,140,600	70,891,111
Average for January–Sept.	4	1,718,379	6,364,310	76	16,255,493	50,564,219

FILTER No. 4.

Year 1906.	No. of Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per Acre per Scraping.
January	7	2,691,480	11,214,500	...	...	...
February	7	2,4.7,385	10,322,437	96	29,361,600	122,340,000
March	5	2,202,120	9,175,500	...	...	...
April	6	1,902,636	6,000,795	104	30,800,340	128,334,370
May	4	902,880	3,762,000	...	...	...
June	4	827,640	3,065,333	...	...	...
July	4	902,880	3,344,000	72	12,188,880	50,787,000
August	5	959,310	3,553,000	...	...	...
September... ...	3	902,880	3,344,000	...	...	...
Average for January–Sept.	5	1,529,801	5,975,618	90	24,116,940	100,487,250

FILTER No. 5.

January	6	2,962,050	8,975,909	...	...	...
February	6	3,082,950	9,342,272	...	...	...
March	5	2,377,700	7,205,151	79	26,839,800	8,133,272
April	5	1,884,025	5,709,166	...	...	...
May	4	1,397,066	4,233,533	74	2,256,800	683,878
June	4	1,289,600	3,907,878	39	10,356,800	31,384,240
July	4	1,289,600	3,907,878	...	...	...
August	4	926,900	2,808,787	...	...	...
September... ...	3	711,966	2,157,472	67	18,941,000	57,396,969
Average for January–Sept.	4	1,769,095	5,360,894	64	14,598,600	25,938,317

FILTER No. 6.

January	5	2,490,900	8,596,206	...	32,735,480	112,880,965
February	5	2,211,125	7,624,568	154	...	...
March	6	2,259,860	7,792,620	...	...	...
April	5	1,646,160	5,676,413	68	19,818,900	68,341,034
May	4	1,155,200	3,983,448	56	12,996,000	44,813,793
June	4	1,155,200	3,983,448	67	14,151,200	48,797,241
July	3	1,155,200	3,983,448	...	...	...
August	4	1,371,800	4,730,344	...	...	...
September ...	4	1,155,200	3,983,448	...	...	...
Average for January–Sept.	4	1,622,298	5,594,882	86	19,925,395	68,708,258

FILTER No. 7.

January	6	2,833,850	9,771,896	...	...	...
February	4	2,036,040	7,020,827	59	17,183,600	59,253,793
March	5	2,156,975	7,437,844	38	13,320,900	45,934,137
April	5	1,754,460	6,049,862	128	14,187,300	48,921,724
May	6	1,444,000	4,979,310	...	...	...
June	...	...	...	...	...	...
July	3	962,666	3,319,537	66	3,754,400	12,946,206
August	4	1,991,637	6,867,713	42	11,343,348	39,114,993
September... ...	4	1,646,160	5,676,413	...	...	...
Average for January–Sept.	4	1,853,223	6,390,425	66	11,957,909	41,234,170

FILTER No. 8.

Year 1906.	No. of Days between Aera-tions.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrap-ings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	7	3,280,666	10,582,793	...	...	...
February	8	3,724,000	12,012,903	...	...	...
March	7	3,848,666	12,415,051	...	...	...
April	7	2,128,000	6,864,516	174	50,700,000	163,538,379
May	4	1,216,000	3,922,580	89	27,664,000	89,238,709
June	3	1,216,000	3,922,580	...	...	...
July	4	1,216,000	3,922,580	...	...	...
August	4	1,216,000	3,922,580	...	...	...
September... ...	3	1,165,333	3,759,138	...	...	...
Average for January–Sept.	6	2,112,296	6,813,867	117	39,182,000	126,388,544

FILTER No. 9.

January	5	1,591,526	5,684,021	83	20,374,200	72,765,000
February ...	4	1,927,660	6,884,500	...	...	...
March	4	1,817,900	6,492,500	...	...	...
April	3	1,189,066	4,246,664	78	10,290,000	36,750,000
May	4	828,933	2,960,475	...	...	..
June	4	782,040	2,793,000	...	...	...
July	3	823,200	2 940,000	...	...	..
August	4	823,200	2,294,000	...	...	...
September... ...	3	823,200	2,940,000	56	9,561,000	34,146,428
Average for January–Sept.	3	1,178,525	4,209,017	72	13,408,400	47,887,142

FILTER No. 10.

January	5	1,605,960	5,735,571	...	...	...
February	5	1,823,040	6,510,857	50	11,284,200	40,300,714
March	4	1,134,600	4,052,142	...	...	...
April	4	926,640	3,309,428	51	7,724,700	27,588,214
May	4	926,640	3,309,428	...	...	...
June	4	741,960	2,649,857	...	...	...
July	3	824,400	2,944,285	42	5,564,700	19,873,928
August	4	1,016,100	3,628,928	...	...	...
September... ...	4	946,266	3,379,523	...	...	...
Average for January–Sept.	4	1,105,067	3,946,668	47	8,191,200	29,254,285

FILTER No. 11.

January	6	2,036,975	7,274,910	30	10,184,875	36,374,553
February	5	1,913,283	6,833,117	28	9,563,425	34,155,089
March	4	1,208,375	4,315,624	...	...	...
April	4	883,840	3,156,581	41	9,183,650	32,798,750
May	3	759,550	2,712,678	52	7,043,100	25,153,928
June	4	828,600	2,959,285	...	...	...
July	4	759,550	2,712,678	...	...	...
August	4	932,175	3,329,195	...	...	...
September... ...	4	828,600	2,959,285	...	...	...
Average for January–Sept.	4	1,127,883	4,028,150	37	8,993,762	32,120,580

FILTER No. 12

Year 1906.	No. of Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.	No. of Days between Scrappings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January	6	1,986,575	7,094,910	42	13,636,958	48,703,421
February	5	1,738,110	6,207,525	...	...	...
March	4	1,236,600	4,416,428	31	10,339,350	36,926,250
April	4	887,425	3,169,374	...	...	...
May	4	783,180	2,797,071	64	11,919,750	42,570,535
June	4	783,180	2,797,071	11	1,648,800	5,888,571
July	4	829,075	2,960,981	...	...	...
August	4	875,925	3,128,303	...	...	...
September... ...	4	824,400	2,944,285	81	10,373,700	37,763,214
Average for January–Sept.	4	1,104,941	3,946,217	45	9,583,711	34,370 398

AERATIONS, AVERAGES FOR ALL THE FILTERS.

Year 1906.	Days between Aerations.	Quantity filtered between each Aeration.	Gallons per acre per Aeration.
January ...	6	2,551,116	9,063,112
February ...	6	2,495,472	8,813,890
March ...	5	2,051,217	7,266,537
April ...	4	1,441,232	5,061,885
May ...	4	1,049,699	3,734,941
June ...	3	972,678	3,606,202
July ...	3	934,394	3,230,470
August ...	4	1,119,070	3,963,330
September ...	3	1,010,394	3,558,442
Average for 9 months from January to September	4	1,513,919	5,363,206

SCRAPINGS, AVERAGES FOR ALL THE FILTERS.

Year 1906.	Days between Scrapings.	Quantity filtered between each Scraping.	Gallons per acre per Scraping.
January ...	...	...	...
February ...	...	...	...
March ...	...	...	...
April ...	...	...	...
May ...	...	...	...
June ...	...	...	...
July ...	...	...	...
August ...	...	...	...
September...	...	...	...
Average for 9 months from January to September	65	15,648,499	51,217,043

RATE OF FILTRATION.

1904. Month.	Average rate of filtration, inclusive of all stoppages for aeration, cleaning and repair. Gallons per sq. yd. per day.	Gallons per acre per day.	1905. Month.	Average rate of filtration, inclusive of all stoppages for aeration, cleaning and repair. Gallons per sq. yd. per day.	Gallons per acre per day.	1906. Month.	Average rate of filtration, inclusive of all stoppages for aeration, cleaning and repair. Gallons per sq. yd. per day.	Gallons per acre per day.
January ...	143	692,120	January ...	186	900,240	January ...	253	1,224,520
February ...	144	696,960	February ...	205	992,200	February ..	251	1,214,840
March ...	159	769,560	March ...	216	1,045,440	March ...	193	934,120
April ...	172	832,480	April ...	214	1,035,760	April ...	153	740,520
May ...	128	619,520	May ...	181	876,040	May ..	135	653,400
June ...	139	672,760	June ...	173	837,320	June ...	127	614,680
July ...	127	614,680	July ...	181	876,040	July... ...	113	546,920
August ...	147	711,480	August ...	173	837,320	August ...	143	692.120
September ...	166	803,440	September ...	172	832,480	September ...	142	687,280
October ...	98	474,320	October ...	157	759,880			
November ...	162	784,080	November ...	119	575,960			
December ...	217	1,050,280	December ...	182	880,880			
Average for 1904	151	726,806	Average for 1905	180	870,796	Average for 1906 (9 months)	168	812,044

PERCENTAGE OF FILTERED AND UNFILTERED WATER CONSUMED.

1904. Month.	Percentage filtered.	Percentage unfiltered.	1905. Month.	Percentage filtered.	Percentage unfiltered.	1906. Month.	Percentage filtered.	Percentage unfiltered.
January ...	44%	56%	January ...	60%	40%	January ...	84%	16%
February ...	41%	59%	February ...	71%	29%	February ...	79%	21%
March	43%	57%	March ...	70%	30%	March ...	62%	38%
April	48%	52%	April	71%	29%	April	48%	52%
May	35%	65%	May	61%	39%	May	40%	60%
June	41%	59%	June	55%	45%	June ...	37%	63%
July	52%	48%	July	58%	42%	July	37%	63%
August ...	59%	41%	August ...	58%	42%	August ...	36%	64%
September ...	52%	48%	September ...	53%	47%	September ...	46%	54%
October ...	32%	68%	October ...	47%	53%			
November ...	56%	44%	November ...	47%	53%			
December ...	79%	21%	December ...	66%	34%			
Average for 1904	48%	52%	Average for 1905	60%	40%	Average for 1906 (9 months)	52%	48%

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